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ABSTRACT

This field guide was especially developed for Water Watch--a public participation program in Kentucky that encourages citizens to adopt a stream, lake or wetland, and then gain hands-on experience in protecting and enhancing their adopted water resources. Understanding the relationships between life and the environment helps people to appreciate water as a vital resource. This field guide is designed to help participants better understand the ecology of the aquatic habitats which exist in the state of Kentucky. The first chapter describes the regions and habitats which can be found within the borders of the state. It also contains many basic definitions that help build the vocabulary necessary to study aquatic ecology. Chapter 2 describes the variety of life that can be found in Kentucky's aquatic ecosystems. The third chapter describes how to sample an aquatic ecosystem. A list of 44 references that would be helpful in studying aquatic life follows the third chapter. Appendices include an explanation of how to diagnose the quality of a stream; a sample field data sheet; identification keys to the algae, aquatic macroinvertebrates, and families of fishes in Kentucky; and a glossary of terms used in aquatic ecology. (CW)

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A Field Guide to Kentucky Rivers and Streams

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WATER WATCH

Kentucky Division of Water

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A Field Guide to Kentucky Rivers and Streams

This field guide was especially developed for WATER WATCH--a public participation program that encourages citizens to adopt a stream, lake or wetland, and then gain hands-on experience in protecting and enhancing their adopted water resource.

This booklet offers an illustrated guide and discussion for field observation along and within Kentucky's rivers and streams. The Kentucky Division of Water hopes it will serve as a working tool in providing your WATER WATCH group a rewarding, learning experience and a greater appreciation of our precious water resources.

Help Yourself to Clean Water
Adopt a Stream, Lake or Wetland

WATER WATCH
Division of Water

Kentucky Natural Resources and
Environmental Protection Cabinet
May 1985
(Revised May 1986)

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Table of Contents

		Page
Chapter 1	Ecology	1
Chapter 2	Aquatic Life	15
Chapter 3	Survey Design	41
References and Additional Readings		51
Appendices		55
Appendix I	Diagnosis	57
Appendix II	Field Data Sheet	61
Appendix III	Key to Algae	67
Appendix IV	Key to Aquatic Macroinvertebrates	79
Appendix V	Key to the Families of Fishes	85
Glossary		107

CHAPTER 1 ECOLOGY

Understanding the relations between life and its environment helps us appreciate water as a vital resource. This chapter discusses these relations and how the natural lay of the land, combined with human activities, affects river and stream ecology.

Kentucky can be divided into five different regions (Figure 1) based on physical characteristics, such as topography and geology. Streams in the state range from slow-moving, muddy (turbid) water in the west, to swiftly flowing, clear water in the east. The following paragraphs discuss some of the more prominent regional features which affect the state's streams.

In the far southwestern portion of Kentucky is an eight county area known as the **Jackson Purchase**. The main feature of the Purchase area is the very level topography. The streams typically consist of meandering, slow-moving water – with rarely a riffle. This region is also known for its choice farmland, which has a major impact on the streams. Row crops (corn and soybeans) often extend to the stream edge, leaving little or no protective riparian (streamside) vegetation. Such farming practices result in high soil (sediment) runoff during rain storms, leading to increased turbidity. Lack of shade also causes warmer waters. Wetlands (swamps) are also common along the streams of the Jackson Purchase, but they are rapidly being converted to cropland.

The **Pennyroyal** is a twenty-six county area in southern Kentucky. The geology of this region is the main influence on the streams. Most of the area is underlain by limestone, a mineral easily eroded by water. Many of the streams flow underground through sinkholes and caverns. Surface streams in the Pennyroyal vary from the clear, swift waters in the east, to the slow-moving, turbid waters in the west.

The **Western Coalfield** covers fifteen counties in western Kentucky. The name reveals the major stream influence. Rich bottomland areas are underlain by coal, a major source of income for the state. Many streams have suffered from acid mine drainage and surface mining sediments. Wetland areas

Figure 1. The Five Regions of Kentucky.

associated with these sluggish bottomland streams have been eliminated or severely degraded by coal mining and agriculture. Part of the coalfield consists of a series of sandstone and shale hills and ridges. Streams in these areas are generally unaffected by mining and are good places to look for native fauna.

Central Kentucky has long been known as the Bluegrass. Although most people think only of the horse farms and major urban centers, this region is made up of thirty-eight counties and includes the hilly land or "knobs" which surround it. The central area has deep, fertile soil over limestone. Some underground streams occur, although surface streams are more typical. These surface streams have moderate flow, with alternating pools and riffles, and many are affected by wastewater discharges from urban centers. The knobs are underlain with sandstone and shale and have steep, often wooded, slopes. The streams generally have cool, swift-flowing water. Runoff from oil well drilling is a problem in some areas.

Eastern Kentucky includes the thirty-three county Eastern Mountain Region. The primary stream influences are coal mining, oil brines and logging. Under natural conditions, the steams drain forested hillsides and are generally clear, cool and swift flowing. However, sediment runoff from mining areas can give them a very turbid or even black appearance. Riffles are more common than pools, because of the steep sandstone, siltstone and shale hills.

In all regions of the state, natural stream flows vary seasonally in response to rainfall. The flows of most streams and rivers are highest in the winter and lowest during September and October (Figure 1).

The Stream System

The stream system (Figure 2) includes the surrounding **watershed**, the **stream channel, instream habitats** and **stream banks**. Because of the influence each of these has on stream organisms, it is important to consider the entire system.

The **watershed** is the total area of land that contributes runoff to a stream. Land uses in the watershed affect the water quality. For example, agriculture, surface mining and urban

areas contribute sediments, organic wastes, nutrients, toxic substances, bacteria, and other pollutants to streams. These disturbances all influence what lives in the water.

The **stream channel** (Figure 2) is created as runoff from the watershed seeks a path of least resistance. If the watershed has very steep terrain, the resulting swift-moving water may cut a deep stream channel and keep the stream bed flushed of sediments. If the topography is flat, the stream may be shallow and meandering, with a substrate comprised primarily of sediments. In Kentucky, we have both kinds of topography and everything in between. In its natural condition, the channel provides a variety of aquatic habitats for many species of plants and animals. These stable habitats provide areas for feeding, resting and reproduction, and generally support a great diversity of organisms.

Instream habitats include pools, riffles, root mats, plants, undercut banks, and a wide variety of substrate materials. These, along with the depth and flow of the water, usually determine the type of aquatic organisms found in the stream. Again, under natural conditions, a great variety of combined habitats means a great diversity of aquatic life.

Stream banks and riparian zones serve many functions other than keeping the water in the channel. They are home to many plants and animals and, under natural conditions, help protect the stream from human influences. When these areas are covered with trees, shrubs and herbaceous (non-woody) plants, they provide shade for the stream, protect the channel from erosion, collect or trap sediments and absorb nutrients -- all helping to improve water quality.

Any natural system, whether in the eastern mountains, central areas or western flatlands, possesses a great diversity of plants and animals. A decline in the number of different organisms (diversity) or the total number of total organisms (density) occurs when the system is in some way disturbed, such as when polluted. Although there are some natural pollutants that can create problems for streams, rivers or lakes, most problems result from human activities. Water pollutants are generally grouped into the following categories: **sediment, organic wastes, nutrients** and **toxic substances**.

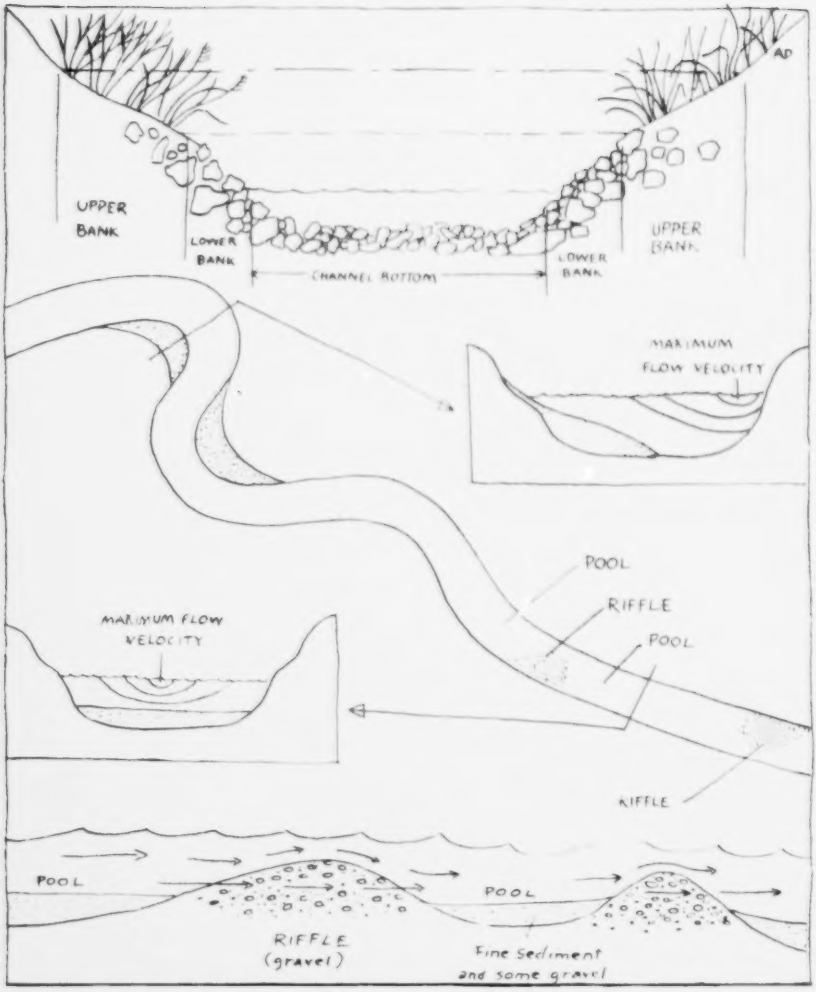

Figure 2. The Stream System.

Diagrammatic representation of water flow and the major structural components of a stream. Note the alternating pools and riffles. A major feature of the riffle is that water flows through the gravel as well as over it. This enables fish eggs and small benthic invertebrates to obtain the oxygen they need while being protected from predation by larger organisms such as fish.

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Sedimentation

Throughout Kentucky, erosion is creating water quality problems. Erosion produces stream sediment loads which exceed natural conditions. Any land-disturbing activity causes soil to be washed into the water. Lands left void of vegetation by agriculture, unpaved roads, eroding roadsides, construction operations, urban areas, forestry and mining activities all contribute **sediment** to creeks and rivers. Agricultural practices contribute much of the total sediment, but the highest erosion rates are associated with construction activities and mining. Excessive amounts of sediment cause many problems in the stream system. For example, sand and silt may fill in the spaces between boulders, rocks, and other obstacles, producing poor riffle habitats and smothering aquatic organisms. Insects, which are a prime food supply for game fish, can be wiped out, adversely affecting the fish population. Game fish may give way to non-game fish or those fish whose existence does not rely on these small organisms.

An overloading of sediments also fills in the stream bed and reduces the channel capacity, which may result in flooding. In the past, attempts have been made to reduce flooding by channelization. The most commonly employed methods of channelization were straightening the channel (eliminating the meanders), dredging the stream and removing vegetation from the stream banks. These practices affect both the immediate stream area and the downstream areas. Effects include the loss of available habitat for fish and other aquatic animals, and an increase in temperature in the now-unshaded portions of the stream.

Organic Wastes

Oxygen is as essential to aquatic life as it is to life on land. The amount of oxygen in water is called the **dissolved oxygen** (DO) concentration and is dependent on the water temperature (the colder the water, the more oxygen it can hold). Oxygen can be taken directly from the air, with the process being enhanced in areas of turbulent water (i.e., waterfalls and riffles). Oxygen is also added from photosynthesis by aquatic plants and algae. Respiration of aquatic organisms and decomposition of wastes and dead plants and animals remove oxygen from the water. The addition and removal of oxygen are generally balanced in normal, healthy streams, and the DO remains high.

Organic material, such as found in wastewater, uses oxygen for decomposition. The amount of oxygen required to decompose waste is called **biochemical oxygen demand** (BOD). When the BOD of the waste exceeds the available oxygen, the DO in the stream is reduced or depleted and is unavailable for fish and invertebrates. Very low DO can cause fish kills.

Sluggish streams are particuarly vulnerable to DO reduction since DO levels are normally lower than in faster, more turbulent streams. In streams with extremely low DO, organisms such as "bloodworms" (midge larvae), worms and air-breathing snails may be the only invertebrates present, but they may be very abundant. High amounts of organic carbon added to a stream may cause extensive growths of "sewage fungus" (actually bacteria) which cover all substrates and prevent other aquatic organisms from living in the stream.

Stream Zones

The entry of pollutants into a flowing stream sets off a progressive series of physical, chemical and biological events in downstream waters. The nature of these changes depends on the kind and amount of the polluting substances, and may adversely affect stream life directly by toxic action or indirectly by alterations of the water qualify or the stream bed.

You can obtain an understanding of stream conditions by observing the populations of plants and animals present in the stream. Some species are tolerant to different degrees of pollutions, while others are intolerant. In a polluted stream, the intolerant species are killed or driven out, and the tolerant

species increase their populations enormously. The presence of tolerant species in moderate or few numbers cannot be considered as an indication of pollution, since they are a part of every natural stream community. However, the absence of intolerant species, combined with the presence of high numbers of tolerant species, indicates that the stream is polluted.

A polluted stream is divided into zones (Figure 4). The extent of each zone depends on many factors, including (1) kind and amount of pollutant, (2) amount of dilution by the receiving stream, (3) ability of the stream to break down the pollutants, and (4) season of the year. The stream zones polluted by organic waste may be generally classified as follows:

1) **Clean Water Zone** - the area upstream of the pollutant discharge usually contains a community of organisms characterized by many species, both tolerant and intolerant, with all levels of the food chain represented. The water is generally clear and fresh, with DO levels high.

2) **Zone of Degradation** - in the area immediately downstream of the pollutant discharge, the water may become turbid and darker, with DO levels beginning to decrease as the waste decomposes. Usually only tolerant species of fishes, invertebrates and algae, are found in this area.

3) **Polluted Zone** - as the waste continues to decompose, much of the stream's DO is used up. The stream may have a **septic odor** and **sludge beds** may develop on the bottom. Only extremely tolerant invertebrates, bacteria and algae can live in this zone; fishes are generally absent, except possibly for short periods. Sewage fungus may be present, even abundant.

4) **Recovery Zone** - as most of the organic material decomposes, the DO of the stream begins to increase. In this zone, tolerant fishes, invertebrates and algae will again be found.

5) **Clean Water Zone** - eventually most of the organic material is decomposed and the water is once again clear and fresh with high DO levels. The aquatic communities contain a wide variety of both tolerant and intolerant

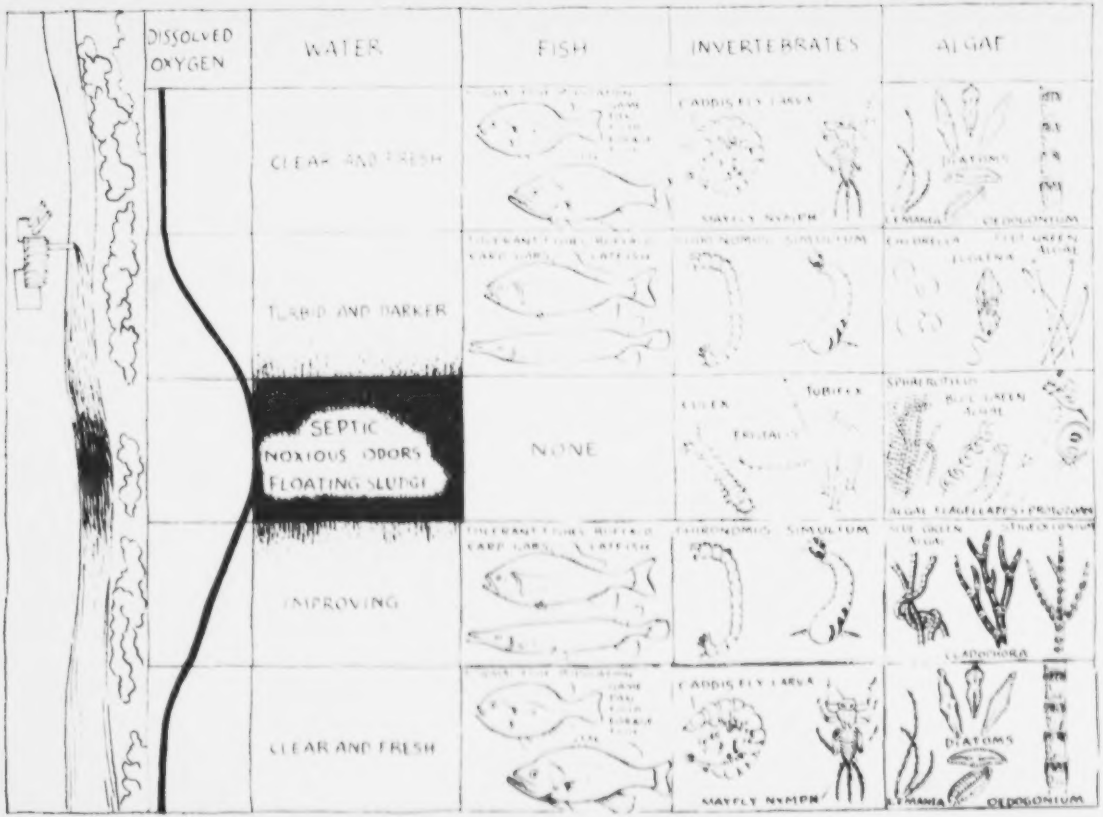


Figure 4.
Stream Zones.

1. **Clean Water Zone**
2. **Zone of Degradation**
3. **Polluted Zone**
4. **Recovery Zone**
5. **Clean Water Zone**

species similar to those found above the source of pollution. If other sources of pollution discharge to the stream, the zones may be extended further downstream. In fact, the stream may never recover.

Other types of pollutants, such as toxic chemicals or brine water, may affect aquatic communities differently. Toxic substances may completely wipe out aquatic life downstream of the source. As you move downstream from the source of pollution, the chemicals are diluted and degraded and a gradual recovery of the biota may occur. Brine water may also kill all animals in the stream. However, some salt-tolerant algae may be abundant, depending on the concentrations of the brine.

Algae are primary producers and form the base of the aquatic food chain (lowest **trophic level**) (see Figure 5). They are able to use sunlight as an energy source to produce food and oxygen for higher organisms such as aquatic macroinvertebrates and fish. Excessive algal growth can ruin the appearance of water as well as interfere with its intended uses, such as causing unpleasant tastes and odors in drinking water. Die-off and decomposition of large algal populations can severely deplete dissolved oxygen concentrations, resulting in fish kills. Some algal blooms may be toxic to both aquatic and terrestrial animals. There have been reports of death or sickness of livestock, pets, and wildlife after drinking water containing high concentrations of certain blue-green algae.

Nutrients

Like land plants, the flora (i.e., algae, mosses, and aquatic plants) of streams, rivers and lakes requires phosphorus and nitrogen to survive. Certain amounts of these **nutrients** are necessary to maintain productive floral populations that serve as primary producers in streams and lakes. These plants provide food and habitat for grazing insects and fish. However, excessive quantities of nutrients can lead to algal blooms or nuisance plant growths, affecting uses of the waterbody.

Nutrient enrichment of surface waters, a process known as **eutrophication**, is largely caused by domestic, agricultural and industrial activities. Sources of nutrients include sewage disposal discharge, septic tank leakage, detergent wastes, fertilizer runoff from residential lawns and gardens, agricultural

cropland and feedlots, as well as factory and distillery effluents. Most of Kentucky's waters contain consideraly greater quantities of nitogren than phosphorus; therefore, the extent of algal growth is determined largely by the availability of phosphorus. This water quality condition is sometimes referred to as "phosphorus limited."

While many municipal sewage treatment plants are efficient in removing solids and other organic wastes, most facilities are not capable of removing much of the phosphorus. The problem is worsened by the widespread use of laundry detergents containing phosphate brighteners. Agricultural (and residential) fertilizer runoff is another significant source of nutrient enrichment. Streams draining agricultural areas generally have about ten times more total phosphorus (and five times more total nitogren) than those streams draining forested watersheds. These quanities of nutrients lead to algal blooms that may affect the uses of streams and lakes.

Toxic Substances

Unfortunately, the present of **toxic substances** (harmful chemicals) in Kentucky's waters has become commonplace. Municipal and industrial wastewater discharges, pesticide and herbicide runoff from agricultural lands, landfill runoff and seepage, and urban runoff are the major sources of toxics in our lakes, rivers and streams.

Toxic substances are divided into two principal categories, acutely and chronically toxic. Acutely toxic chemicals cause almost immediate harm to organisms (i.e., death) generally over a period of 96 hours or less. Chronically toxic substances are harmful only after long-term exposure, generally the entire lifetime of an organism. A chemical in high concentrations may result in acute toxicity, while low levels of the same chemical may result in death or disease (chronic toxicity) after months or even years of exposure.

Toxic chemicals also may result in deformities, cancer, mutations, growth reductions, alterations in reproduction and behavioral modifications in exposed aquatic organisms. Examples of behavorial modifications include movement from

the affected area (avoidance), disorientation of the animal, cessation of feeding, and an increase or decrease in aggression toward another animal. Any of the above effects may be called a **toxic response.**

Bioconcentration, biomagnification and **bioaccumulation** are terms often used with regard to toxic substances. The movement of a toxicant into an organism from the surrounding water is termed bioconcentration. A chemical may not be toxic to a particular organism, but it may reach toxic levels as it "moves" up the food chain (the animal that ate the animal that ate the animal, etc.) or is biomagnified. Bioaccumulation of toxic substances in organisms is outlined in Figure 3. For example, a toxicant may enter the lower food chain by being eaten or absorbed and become bioconcentrated by a plant or animal. These organisms are, in turn, consumed in vast quanities by other animals and the toxicants are concentrated in their bodies. As you proceed higher in the food chain, successively higher concentrations of toxins will be found. Ultimately, they may become concentrated in humans or other animals high on the food chain. Bioaccumulation is the general term used for the combination of bioconcentration and biomagnification of toxic substances into organisms.

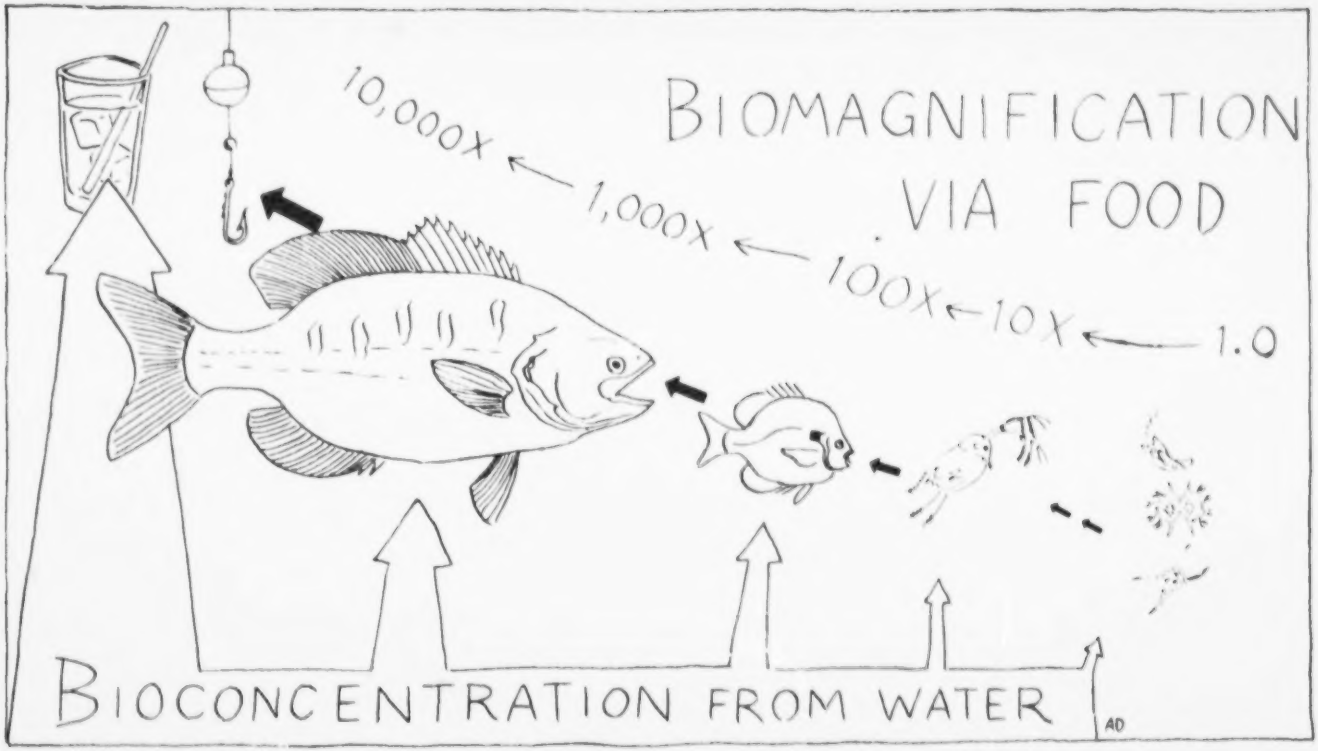


Figure 3. Bioaccumulation of Toxic Substances in Organisms.

CHAPTER 2 AQUATIC LIFE

Bacteria

Bacteria have long been an indicator of drinking water and recreational water quality. While most bacteria are considered microscopic, some may be visible in the stream. Their presence is extremely significant.

Total and fecal coliform bacteria are the most widely used "indicator bacteria." Fecal coliform bacteria are commonly found in the small intestine of humans and other warm-blooded animals. They are not necessarily harmful, but are often associated with harmful bacteria found in various water sources (i.e., rivers, lakes, wetlands).

Sewage fungus, which is a type of bacteria, is a sensitive indicator or organic pollution in flowing waters. Any growth of slimy, cottony-wool-like plumes (usually white, grey, or brown), generally in massive amounts, indicates "sewage fungus", "iron bacteria" or "slime bacteria." For example, sewage fungus often appears in streams receiving waste from paper mills, sugar refineries, canneries, breweries, alcohol refineries and municipal sewage. Sewage fungus is usually observed as long streamers clinging to twigs, leaves, or even the sides and bed of the stream. Should you find a growth such as this, continue upstream until you find the source of the organic pollution.

Should a water sample for coliform analysis be necessary, contact the Kentucky Division of Water to express your concern about collecting a sample. Sterile collection bottles will be furnished and instructions provided on correct sampling procedures.

Algae

Algae attract attention for many reasons, partly because of their bright colors or, more often, due to their nuisance growths in nutrient-enriched streams, ponds and lakes. While the majority of freshwater algae are microscopic, the more obvious forms are often referred to as "pond moss" or "scum." Slick rocks in streams are often due to algal growths.

There are two broad categories of algae: plankton and periphyton. **Plankton** are organisms which are suspended (i.e., free-floating) in the water. Planktonic algae are typically found in ponds, lakes, slow-moving rivers and sometimes in pool areas of streams. **Periphyton** are organisms attached to the stream bottom, rocks, submerged logs, vegetation or other surfaces. Dense growths of attached algae (e.g., *Cladophora*) often occur downstream from municipal sewage treatment plants or in agricultural areas. Attached algae are typically found in streams, rivers and around lake margins. High quality streams and lakes contain sparse to moderate amounts of algae, assuring an adequate food supply to maintain productive macroinvertebrate and fish communities. Waters with little or no algae may be affected by toxic substances or located in low-nutrient watersheds. In general, waters draining limestone areas have greater algal abundance than those draining shale and sandstone regions. As you can see, algae are good water quality indicators.

Certain attached algae may be recognized by the unaided eye. The filamentous green alga *Cladophora* forms coarse, bushy, dark-green to brownish-green masses in streams. The filaments (strands) are frequently long, sometimes three to four feet in length. *Lemanea*, a red alga, occurs in swiftly-flowing waters. It is typically one to eight inches long, olive-green to black in color, and rather stiff compared with *Cladophora*. Another red alga, *Batrachospermum*, is commonly found in or below springs. It is dark olive-green to black in color and characterized by compact, gelatinous (slimy) masses. Fluffy, felt-like masses occurring on rocks or other surfaces are usually diatoms (if the mass is brown to golden-colored) or blue-green algae (if the color is dark green to black).

Common still-water algae include *Spirogyra* (pond silk) and *Hydrodictyon* (water net). *Spirogyra* forms bright green mats of silky filaments which frequently contain trapped bubbles of oxygen. The appearance of these mats is sometimes slimy, which probably led to the common name, "pond scum." *Hydrodictyon* is characterized by green tubular nets, sometimes approaching lengths of six inches or more. The texture is coarse and the nets are readily recognizable. Other algae may be identified using the Field Identification Guide (See Appendix III).

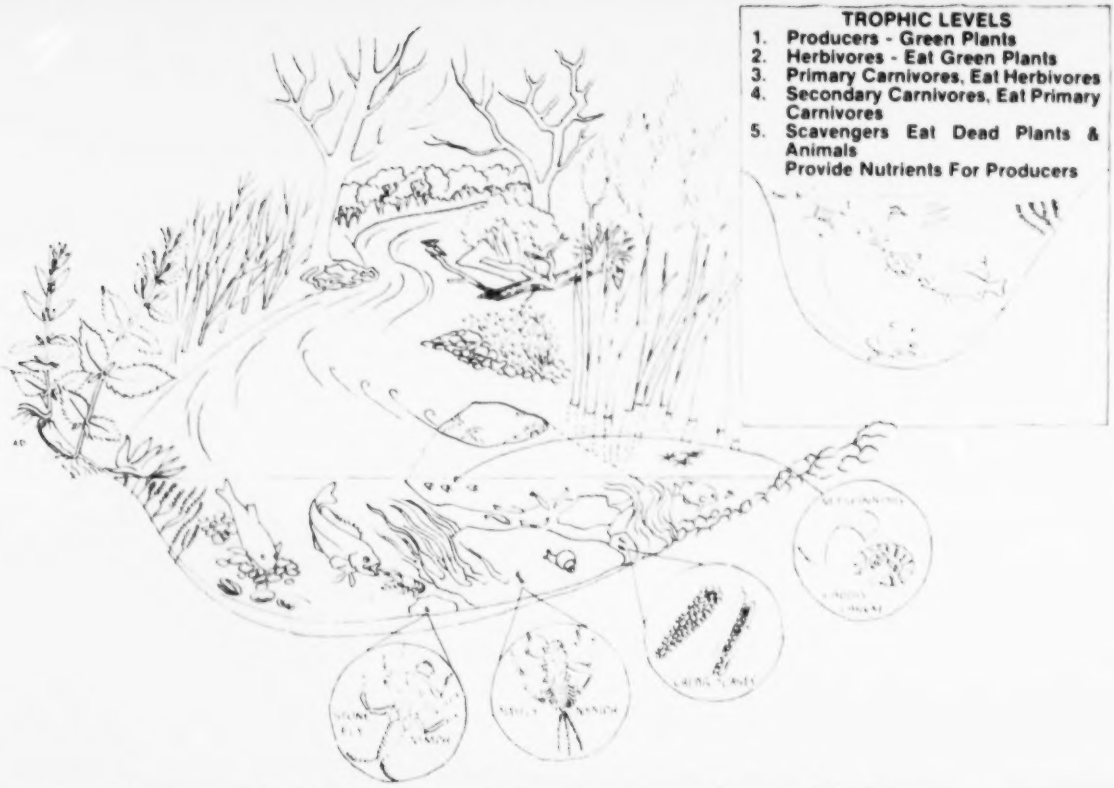
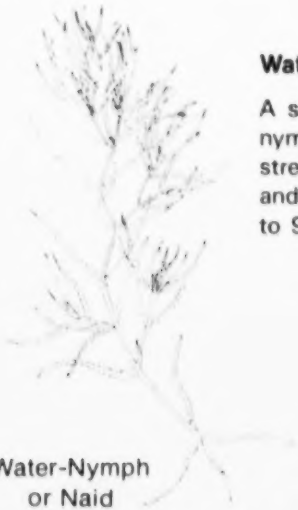

TROPHIC LEVELS
1. Producers - Green Plants
2. Herbivores - Eat Green Plants
3. Primary Carnivores, Eat Herbivores
4. Secondary Carnivores, Eat Primary Carnivores
5. Scavengers Eat Dead Plants & Animals
Provide Nutrients For Producers

Figure 5. The Aquatic Food Chain: Interrelationships Among Aquatic Life Forms.

Plants

Plants that grow along streams provide many benefits. Riparian plants help to stabilize the banks, improve water quality, minimize erosion and collect sediments and nutrients from surface runoff. These areas also provide food and cover for invertebrates, fish and wildlife. Aquatic (growing in the water) plants stabilize bottom sediments and provide oxygen, food and shelter for aquatic organisms. The following list contains a few of the more common aquatic and riparian plant species.



Water-Nymph
or Naid

Water-Nymph *(Najas minor)*

A submerged aquatic plant, the water-nymph can be found in pools or sluggish streams. It has narrow, ribbon-like leaves and very long, many-branched stems (up to 9 feet).

Coontail

Coontail *(Ceratophyllum demersum)*

This plant also grows entirely under the water. It, like the water-nymph, can be found in slow-moving streams. The narrow, thread-like leaves cause the coontail to be confused with algae.

Pondweed

Pondweed *(Potamogeton* species*)*

Rooted in the stream bottom, pondweeds, have submerged, thread-like leaves oval floating leaves, or both. When you see oval-shaped leaves floating in pool areas of streams, it may be this aquatic plant. It can reach a length of 4 feet.

Water Willow *(Justicia americana)*

The commonly occurring water willow has pale violet flowers in head-like clusters on long stalks and leaves that look like those of a willow tree. The stem is commonly 1½ to 3 feet tall and is found on sand and mud and gravel bars of slow-moving streams throughout the state.

Water Willow

Water Primrose *(Jussiaea repens)*

This plant grows at the water's edge. Slow-moving streams will often have water primrose rooted in the lower banks or mud bars. It has long stems, with floating, lance-shaped leaves and yellow flowers extending into the water.

Water Primrose

Smartweed

Smartweed *(Polygonum species)*

Sprawling, many-branched plants, smartweeds often form dense growths along steam banks. They have long, narrow leaves and twining stems, occasionally with sharp barbs that are painful when rubbed against the skin. The white or purple flowers appear as clusters on short stalks.

Stinging Nettle

Stinging Nettle *(Laportea canadensis)*

Although this common floodplain plant appears harmless, even inconspicuous, it can be very painful to touch. It you ever walk through a patch of stinging nettle, you will know it by the burning sensation up and down your legs. It can grow waist high and has large oval leaves. The stem is covered with tiny "hairs" that contain a skin irritant.

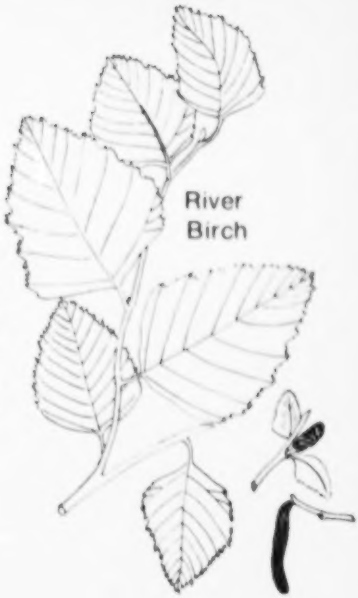
Black Willow

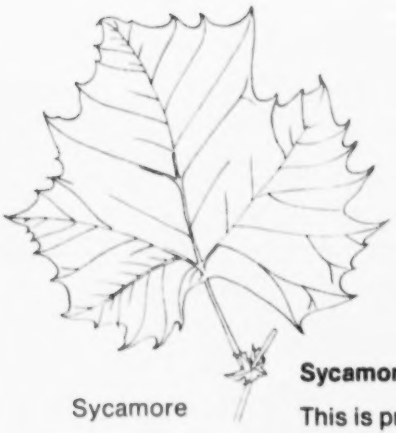
Black Willow *(Salix nigra)*

This tree grows 30 to 40 feet tall and often has a cluster of several trunks emerging from one base. The leaves are 2½ to 5 inches long and lance-shaped. Black willows occur along streams throughout Kentucky.

River Birch *(Betula nigra)*

The river birch frequently grows along stream edges in most sections of Kentucky except the Bluegrass. It may be 50 to 75 feet high and have two or three trunks from one base. The leaves are 1¼ to 3½ inches long and wedge-shaped at the base. A common characteristic is the shaggy, paper-like bark.

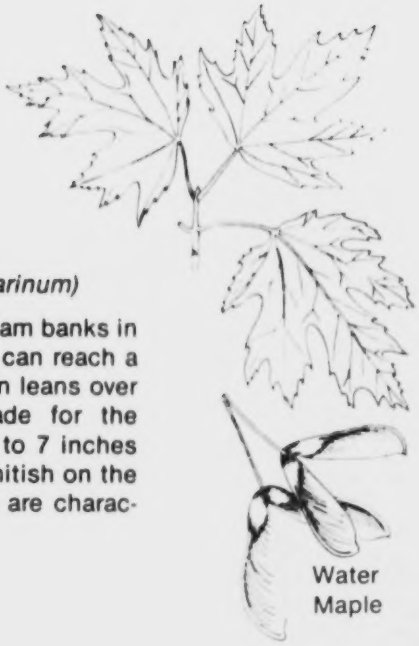




Sycamore

Sycamore *(Platanus occidentalis)*

This is probably the most characteristic streamside tree in the entire state. The distinctive brown and white sycamore can be massive, up to 130 feet high, with very wide spreading branches. The leaves are 4 to 7 inches long and have a fuzzy coating on the underside. The small, round fruits seen hanging from limbs and twigs are an obvious feature.



Water Maple

Water Maple *(Acer saccharinum)*

This tree grows along stream banks in every Kentucky county. It can reach a height of 90 feet and often leans over the water providing shade for the stream. The leaves are 3 to 7 inches long, deeply lobed and whitish on the underside. Winged seeds are characteristic.

Macroinvertebrates

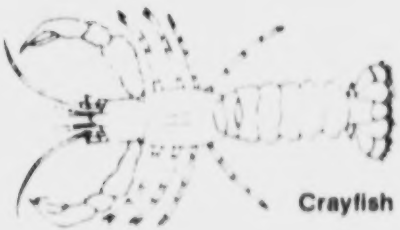
This section introduces you to aquatic macroinvertebrates. "**Aquatic**" means that the animals live in water. "**Macro**" refers to the fact that they are big enough to be seen with the naked eye. "**Invertebrate**" means that the animal lacks a backbone.

Each type of macroinvertebrate has a preference for certain living conditions. For example, some prefer to live in riffle areas, while others are commonly found in pools. (Methods used to find these creatures are discussed later in Chapter 3, Survey Design). The following is only a brief discussion of macroinvertebrates and some general characteristics of the varieties you may encounter in a stream. Use the pictures in Appendix IV. If you feel ambitious or just want to confirm your identification, use the simple key.

Crustaceans (Class Crustacea)

Crayfish and Freshwater Shrimp (Order Decapoda)

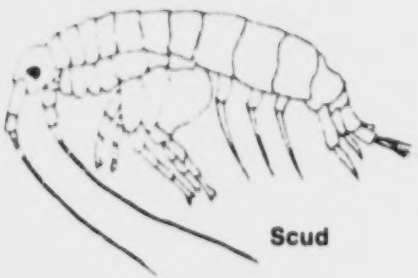
Crayfish and freshwater shrimp are among the largest of the invertebrates you will collect. Crayfish, resembling tiny lobsters, hide within the stream banks or under rocks and logs. Their coloration includes brown, orange, black and sometimes blue. Most are moderately tolerant of pollution. Freshwater shrimp, on the other hand, are almost transparent. They may be found in slow areas of most rivers and large streams.



Crayfish

Scud (Order Amphipoda)

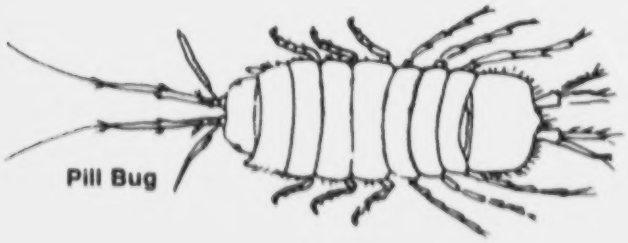
Scuds or sideswimmers are common and widespread. Their bodies are cresent shaped and creamy white to tan-gray in color. They move about by skittering on their sides and flexing their entire body. In general, they are found hiding in vegetation or under debris in most waters of the state. They are moderately tolerant of organic pollution.



Scud

Isopod (Order Isopoda)

Isopods, commonly called pill bugs, are similar in shape to a caterpillar flattened front to back with legs extending on either side. They seldom inhabit open waters, but instead remain hidden under rocks, vegetation and debris. Isopods are typical inhabitants of small-to medium-sized streams or wetlands. They are moderately tolerant to organic pollution.



Pill Bug

Snails (Class Castropoda)

Snails inhabit almost every conceivable type of freshwater environment -- from the smallest ponds and streams to the largest lakes and rivers. There are approximately 500 species of aquatic snails that occur in North America, one-third of which are found in Kentucky's waters. The actual number of aquatic snail species occurring in Kentucky is unknown because this group has not been extensively studied. Gastropods come in a variety of sizes and shapes, but most have a coiled shell and a muscular "foot" (Figure 6, A). The "foot" protrudes from the bottom of the shell and is used for movement. One group of snails, the limpets, resembles a coolie hat. Snails are animals of the substrate and may be found creeping about on all types of submerged surfaces. The vast majority of freshwater snails eat algae. As they move about, they form irregularly shaped tracks in the sediment. Some species are quite intolerant to pollution, while others are tolerant, but none can withstand very acidic waters.

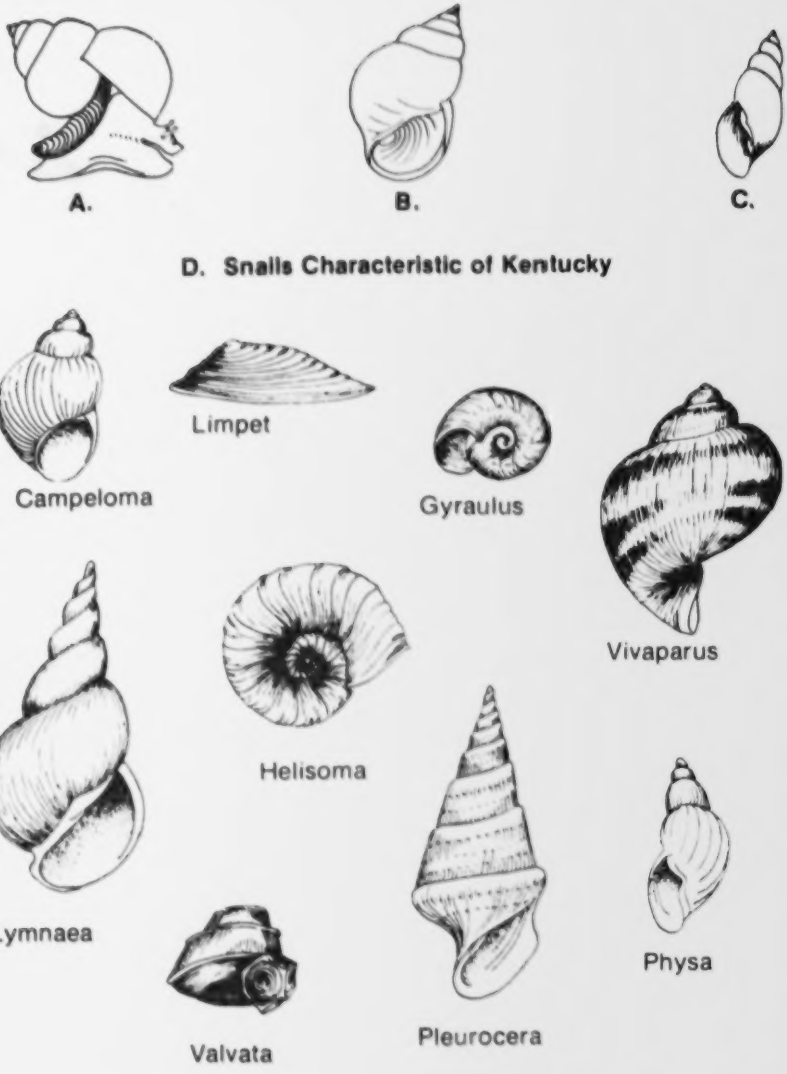


Figure 6. Morphology and Types of Common Freshwater Snails.

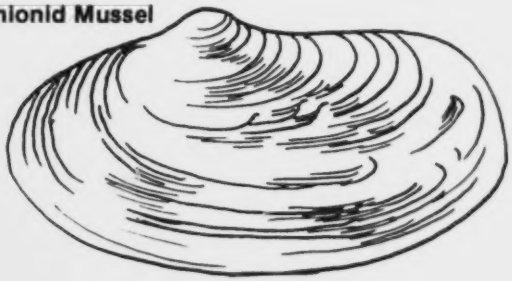
A. Operculate Snail
B. Dextral Shell
C. Sinistral Shell
D. Snails Characteristic of Kentucky

Mussels and Clams (Class Pelecypoda)

The mussels are characterized by having shells consisting of two halves connected by an elastic hinge. Mussels are found in all aquatic habitats but they are most abundant in medium- to large-size streams. At least 120 species of native freshwater mussels and fingernail claims, and one asiatic clam (*Corbicula fluminea*) are found in waters of the Commonwealth. Unlike snails, mussels have no head; the only thing protruding from the shell is the foot. Most freshwater mussels prefer sand and gravel substrate in areas with a current (riffle areas). Clams have less stringent requirements, being found on all types of bottoms. Mussels and clams do not move over large distances during their life; they anchor themselves into the substrate with the aid of their muscular foot. These animals filter-feed with a pair of tubes called siphons. Their diet consists of microscopic plants (**phytoplankton**), animals (**zooplankton**) and organic debris.

Throughout human history in North America, snails and mussels have been used by man as a food source. The shells were used for jewerly and tools by American Indians. From the early to mid-1900's, mussel shells were harvested and manufactured into buttons. During the past few decades, freshwater mussel shells have been used in the Japanese cultured pearl industry.

Unionid Mussel



Fingernail Clam

Insects (Class Insecta)

There are a great number of insects inhabiting the aquatic environment. Some insects spend their entire lifespan in the water, while others live there only when they are young (**pupa, larva** and **nymph** stages). Some insect groups are extremely sensitive to pollution. Members of the first three orders listed below can be especially sensitive and are good indicators of water quality.

Stoneflies (Order Plecoptera)

Stonefly Nymph

If you are an angler, you may already be familiar with these insects. They spend the nymphal stages of their life in the water and provide a good food source for fish. Their bodies have two tails extending from the rear area and each leg ends with a double hook. Their color ranges from white, tan, yellow or brown to a glossy black. Some even appear to be clad in an armor, exquisitely decorated in yellows and deep browns. Generally, these insects are slow moving, living in protected areas of debris, leaves or under stones. Many species are voracious predators. They prefer clean, cool waters where there is a good supply of oxygen. The group as a whole is sensitive to pollution.

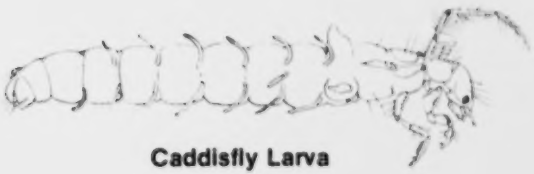
Mayflies (Order Ephermeroptera)

Mayfly Nymph

Mayflies are very similar in shape to the stoneflies. However, they usually have three "tails" and possess one hook at the end of their legs. Mayflies are often brighly colored. These creatures dart, crawl, cling, sprawl and burrow. The burrowers actually plow their way through mud, using "tusks" that project from their heads as a digging mechanism. Mayflies inhabit all types of freshwaters where the oxygen supply is good. Most species prefer clean water. Like stoneflies, mayflies spend their nymphal stages in the water. Generally, the nymphs require from three months to a year to mature, at which time they emerge from the water as adults. This in itself is not unusual. However, one genus of this group (*Hexagenia*), a burrowing mayfly, emerges in a huge mass. Adult mayflies are often seen in the spring, summer and fall, awkwardly flying over streams.

Caddisflies (Order Trichoptera)

The caddisflies are a group of insects sensitive to pollution. They are soft and often delicately colored insects that inhabit all varieties of habitats. Many build beautiful, intricate cases of stone, leaves and sticks. Do not be flabbergasted to find a stick apparently scurrying among your sample. Peer closely at the twig (or twigs), you'll see the dark head of a caddisfly poking out of the end. Some caddisflies with large leaf or twig cases are restricted to calm waters, while those cased in heavy stones live in swifter environments. A number of stream or river species (those living in flowing waters) actually construct complex nets for the purpose of trapping food from the moving water. The uncased caddisflies are usually found clinging to leaves, rocks and logs.



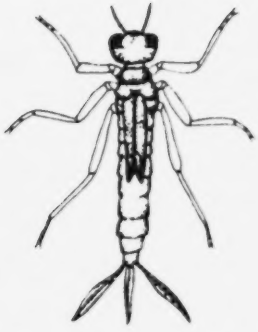
Caddisfly Larva

Case

The remainder of the aquatic insect groups are less sensitive to the quality of their environment. There are individual species within these groups, however, that are sensitive to pollution.

Dragonflies and Damselflies (Order Odonata)

The aquatic larvae of dragonflies and damselflies metamorphose into those elegant, winged creatures you've probably seen near streams, rivers and lakes. The larva itself is a rather bizarre-looking creature. It is elongated, and gray, black, brown, orange or green in color. All of these larvae possess a structure called a labium. The labium, a food-gathering device, is normally found folded backward upon itself underneath the head. It is flat and hinged, and can be extended out from the body. The labium can be as long as one-fourth the size of the body. All species are predatory. You'll find these insects in submerged vegetation or in the bank regions of streams and ponds. Large logs are also good collection sites. Burrowing forms sometimes make trails in sandy, backwater areas. You might sight trails along the stream banks in shallow areas.



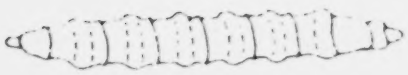
Damselfly Nymph

Dragonfly Nymph

Flies and Midges (Order Diptera)

Flies and midges partially comprise the order *Diptera*. The adults are not aquatic, but many have immature stages living in water. The three most frequently found groups are blackflies (Simuliidae), craneflies (Tipulidae) and midges (Chironomidae). Larvae occur in every type of freshwater environment. Aquatic diptera larvae have greater variability in body structure than any other groups of aquatic insects. However, their general distinguishing features include an elongated, wormlike body and an absence of true legs. Colors frequently observed are black, brown, red, yellow and white. Wiggling and creeping body movements are their means of locomotion.

Horsefly Larva

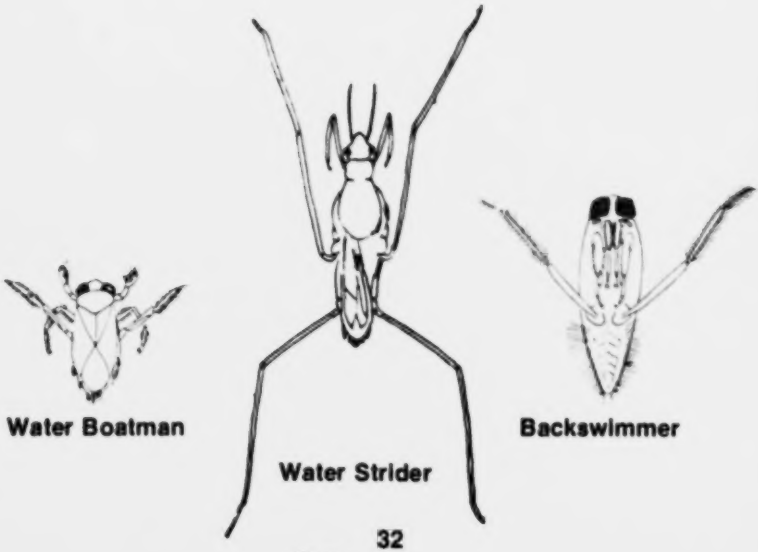


Midge Larva

Black Fly Larva

True Water Bugs (Order Hemiptera)

Water boatmen, backswimmers and water-striders are interesting bugs to watch. They have long, flattened hind legs, similar to oars, which are used to dart about on and within the water. They also have long, sharp snouts used for feeding. They are entirely aquatic and remain in the water except when flying. The water boatmen are somewhat flattened and are usually dark gray, brown and black. They live in the shallow, slow-moving sections of streams, rivers or ponds. The adults are strongflyers and may migrate to other water bodies. Backswimmers, as the name implies, swim on their backs. They are powerful swimmers, using rapid, oar-like strokes. They have unusually large eyes and show considerable color variation with patterns adorning their head and body region. These insects are abundant in the backwaters of streams, ponds and small lakes, often found resting on the surface upside down or clinging to submerged objects. The semi-aquatic waterstrider is (naturally) found "striding" on the water surface of streams and rivers. You will see them from early spring to late autumn under overhanging banks or in other shaded areas. Their long legs are specially modified so they can skate over the water surface, without piercing the surface film.



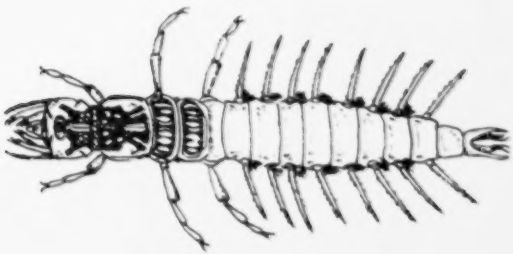
Water Boatman

Water Strider

Backswimmer

Dobsonfly (Order Megaloptera)

Alderflies, dobsonflies (Hellgrammite, "grampus" or "go-devils") and fishflies are very striking in appearance. Mature larvae possess lateral, cylindrical projections and have elongated, stout bodies bearing dull colors of yellow, brown and tan (often they are mottled). The fierce appearance of some species is indicative of the predatory behavior they possess. Depending on the species, you can find them in all types of aquatic habitats. Fishing enthusiasts find this insect to be one of the finest of all live baits.



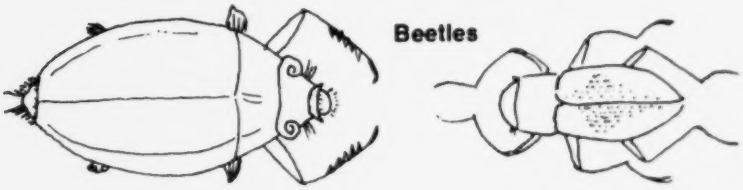
Dobsonfly

Beetles (Order Coleoptera)

Some beetle species live their entire lifespans in the water. The adults have the ability to crawl, swim or fly. Some rely on atmospheric oxygen to breathe. This type of beetle stores its oxygen in water bubbles. The bubbles are held in place by fine hairs on the stomach. One such beetle, the "silver beetle", derived its name from its bubble -- the film of water gives off a silver-like appearance. The adults are often located in shallow areas on vegetation or debris. Many are found clinging to sticks or logs. One type of beetle, the whirley-gig beetle (*Gyrinidae*), is an amusing animal. It literally twirls about on the water surface.

Beetle larvae are completely different from the adults in their appearance. Similar in shape to the megalopterans,

they are elongated, slender and sometimes flattened. Some are able to swim, others crawl or walk. Beetle larvae are usually found in the same habitats as the adult.



Beetles

Worms (Class Oligochaeta)

Aquatic worms possess the same fundamental shape as the terrestrial earthworm, but most have a more delicate body. Many crawl, although there are a few swimmers. You'll find them in all areas, especially burrowing in mud and sand.

Leeches (Class Hirudinea)

Last we come to a discussion on the dreaded Leech! Tradition has endowed the leech with an evil and mysterious aura, stemming mainly from medicinal folklore (and the often slimy appearance of the animal). One prime example was the common use of leeches by the medical profession to bleed their patients, which sometimes resulted in the patient's death. Contrary to our wild imaginations, only a few species of these creatures will take blood from an animal. Most are nonparasitic, finding their food by scavenging and predation. Oftentimes they are quite beautiful, brightly colored and patterned. Wormlike but flattened, they possess suction disks on either end of their bodies. Leeches occur in shallow, warm waters on submerged objects.

Leech

Fishes

Most people can accurately identify game fishes. Other fishes, such as carp, are notorious by reputation. Many fishes, however, are less obvious to the average person. Because fishes live underwater, we rarely observe them as they normally live, and we understand their ecology only vaguely. All fishes are valuable, because each is a small but unique part of the natural system in which all organisms, including humans, depend on one another. Fishing is a part of the outdoor experience that helps make Kentucky a good place to live and is important to the economy of the Commonwealth.

Kentucky has one of the most diverse fish faunas of any inland area of North America. Presently, 229 species are known to occur or to have occurred in Kentucky waters, with only 10 or 11 of those species introduced by man. Some species are extremely limited in distribution and occur nowhere else in the world.

In recent years, many of our fishes have suffered serious declines in populations, chiefly because of human activities. Habitat loss and pollution threaten the survival of many species. Watershed impacts, such as strip mining and construction, and habitat alterations, such as channelization and draining of wetlands, have also decimated many sensitive species.

Fish are usually present, even in the smallest streams and in all but the most polluted waters. The fish community of a stream generally includes a range of sepcies that represents a variety of trophic (feeding) levels. These trophic levels include herbivores (plant eaters), planktivores (plankton eaters), omnivores (plant and animal eaters), insectivores (insect eaters) and piscivores (fish eaters). The foods may be of aquatic or terrestial origin. A fish community in which one or more of these trophic levels are missing or severely reduced could indicate pollution or other impacts in the stream. Some fish are also more tolerant to different types of pollution (organic enrichment, siltation, etc.) than others. The following tables show some of the more common species in each food group and the tolerance of various groups.

Table I. Feeding Groups

Planktivores	-	filter plankton from water
		Paddlefish (spoonbill) Young of many species
Herbivores	-	scrape algae off rocks or eat vegetation
		Stoneroller Silvery minnow
Omnivores	-	eat both plants and animals
		Shad Bluntnose minnow Creek Chub Carp Buffalo fish Carpsucker Channel catfish Bullhead catfish Common shiner Redbelly dace Redhorse suckers
Insectivores	-	eat aquatic or terrestrial insects, may also each small fish
		Many shiners and minnows Darters Bluegill and other sunfish Topminnows Mosquitofish White sucker and spotted sucker Madtoms Hogsucker

Piscivores	-	eat fish, crayfish and insects

Bass; largemouth, smallmouth, spotted
Crappie
Rock bass
Gar
Bowfin
Muskellunge and pickerel
Flathead catfish
Sculpin
White bass and stripped bass
Sauger and walleye
Drum (white perch)

TABLE II. Fishes Tolerant of Turbidity and Silt

Shad
Goldfish
Carp
Bluntnose minnow
Bullhead catfish
Crappie
Drum (white perch)
Green sunfish
Bigmouth buffalo
White sucker
Some minnows and shiners

TABLE III. Fishes Tolerant of Low Dissolved Oxygen

Bowfin
Gar
Mosquitofish
Carp
Bullhead catfish
Pickerel

TABLE IV. Intolerant Fishes

Most darters
Hogsucker
Most redhorse suckers
Spotted sucker
Rock bass
Trout-perch
Madtoms
Sculpin
Silverside
Smallmouth bass
Chubs
Many minnows and shiners

Because of the abundance of common names (the same fish may have different names in various regions of the state) and because many small, lesser known fish have no common names, it is important to be familiar with scientific names of fish. The scientific name consists of two parts, the generic name (genus) and the specific name (species). For example, the scientific name of the largemouth bass is *Micropterus salmoides* and the smallmouth bass is *Micropterus dolomieui*. The genus name *Micropterus*, which both share, shows a relationship between the two fish, while the species name, *salmoides* or *dolomieui*, shows each to be a unique type. Genera of fishes which have some characteristics in common are grouped into families. The genus *Micropterus* is placed in the sunfish family (Centrarchidae) which also includes bluegill and other sunfish (genus *Lepomis*) and crappies (genus *Pomoxis*). Some of the more common families of fish are discussed below. A key to the families, with drawings of representatives, is presented in Appendix V.

Minnows (Family Cyprinidae)

Minnows are usually small fish, but some, such as carp and goldfish, can grow quite large. There are over 60 species of minnows in Kentucky, many of which can be distinguished only by experts. Minnows occupy nearly all types of aquatic habitats and serve as food for many game fish. Chubs, shiners, daces and stonerollers, along with the bluntnose minnows, fathead minnows, and golden shiners sold by bait shops, are the more common species. Not all small fish are minnows, many are the young of other species.

Suckers (Family Catostomidae)

Suckers are closely related to minnows, but can generally be recognized by their thick-lipped (sucker-like) mouths. Most are bottom feeders, sucking up small plants and animals. Some, such as buffalo fishes, carpsuckers and red horses, are important commercial and food fishes.

Catfish (Family Ictaluridae)

The catfishes are easily recognized by their broad flat heads, barbels (whiskers) around the mouth, and scaleless bodies. Channel catfish, flathead catfish and blue catfish are important food fish. Smaller species, such as bullheads and madtoms, are found in many streams.

Sunfish (Family Centrarchidae)

This family contains many easily recognized game and pan fish. Smallmouth, largemouth and spotted bass, rock bass, bluegill and crappie are the main species sought in lakes, ponds and streams of the Commonwealth. Sunfish feed on small fish, crayfish and other invertebrates.

Perches (Family Percidae)

This family includes game fish such as walleye and sauger, along with a large group of small, colorful fishes known as darters. Most darters are adapted to riffle areas of small streams, although some are found in large rivers or even wetlands. Their bright colors, especially during the spring breeding season, make them stand out in shallow areas of a stream.

CHAPTER 3 SURVEY DESIGN

Before getting your feet wet, the group should first determine their long and short term goals (see objectives below) and become familiar with the stream. At this point, a driving tour of the watershed can be useful. This allows you to acquaint yourself with the lay of the land and the various land use activities occurring in the drainage basis. In conjunction with the driving tour, walk or canoe along as much of the stream channel as possible. This will provide information on stream size, habitat types, stream drop (gradient) and riparian (streamside) vegetation development, as well as scenic qualities of the stream.

Objectives

The objectives of stream studies are quite varied. However, two objectives of learnings about a stream are to (1) determine present day conditions (biological, physical and/or chemical) of the stream, and (2) watch the stream for a period of time to determine if it is improving, remaining the same, or getting worse.

Study Area Selection

In choosing study areas, getting to the stream is of primary concern. You should consider the lay of the land, distance to be traveled, steepness of the stream banks, water depth and water speed. If you must cross private land, seek permission from the owner. Deep or fast-flowing waters are difficult and possibly dangerous to sample, and require special equipment and techniques not covered in this manual.

When selecting a specific stream section to watch, try to insure that major stream habitat types, i.e., pools and riffles, are present. Note and record the presence of undercut banks, weedbeds, rock ledges, backwater areas, etc., on appropriate data sheets (Appendix II). Avoid areas around bridges, since they are not typical of unaltered streams. In streams with good water quality, the greater the variety and stability of habitats, the greater the diversity of aquatic organisms. Slow-moving streams occurring in areas of well-developed floodplains may lack some of the habitat types mentioned above. In this event, sample the available habitats extensively.

Survey Types

Three types of surveys are used when studying a stream: 1) the visual survey, 2) the biological survey, and 3) the water sampling survey. The visual survey should always be conducted in conjunction with the other two. The water sampling and biological surveys may be conducted in combination or separately.

Visual Survey

The visual survey is the simplest of the survey types, but it can provide a great deal of information about the stream, while requiring little equipment. Basically, you'll need a clip board, pencils, data sheets (Appendix II), maps, problem diagnosis section (Appendix I) and, if possible, hip boots and a camera. You may also wish to take a walking stick of known length for balance, probing, and depth and width measurements. For safety reasons, the visual survey should be conducted by more than one person. Besides, two or more people will do a better job describing the characteristics of the stream.

During the visual survey, the participants should map the stream or stream section. The map does not have to be a perfect likeness of the stream, but it should include the major habitat types (riffles and pools), dams, bridges, location of discharge pipes, and dumps. Make notes on the data sheet regarding stream depth and width, substrate types (rocks, sand, mud, etc.), types of riparian vegetation (grasses, shrubs and/or trees), adjacent land use and unusual stream odors or colors. A sample map is presented in Figure 7. A camera is useful in recording the various natural or unnatural stream characteristics listed above. Be sure to label all pictures with proper location, date, time and names of photographer and witnesses.

Biological Survey

Biological surveys of streams usually involve collecting algae, aquatic macroinvertebrates and fish. Data from these collections can be used to determine past and present water quality, as well as to determine if the stream is improving, degrading or remaining the same over a period of time.

The equipment required to collect algae from streams is easy to obtain and inexpensive. Collection equipment includes a

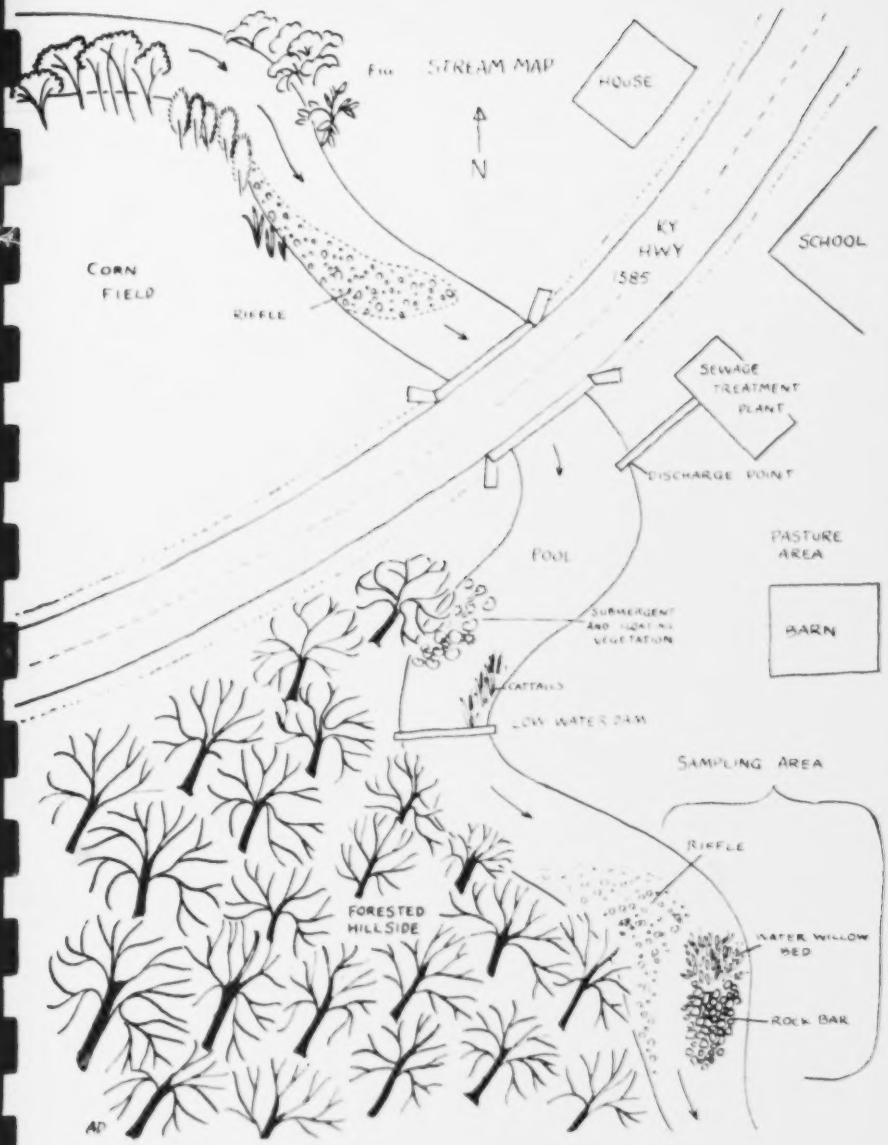


Figure 7. Stream Map.

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knife to scrape algae from rocks and sticks, small jar and zip-lock plastic bags. Observations are best made in the field and recorded on the field data sheet. See Appendix III for Field Identification Guide.

Sample the macroinvertebrates by using fine mesh nets or screens and by picking organisms directly from substrates (rocks and sticks). Identify the invertebrates and release them or preserve them in a 70 percent alcohol solution. Isopropyl (rubbing) alcohol is a suitable preservative and can be purchased from any drug store.

When collecting invertebrates from riffles, place the collecting net or screen firmly on the stream bottom approximately two feet downstream of where you are standing. Agitate the substrate with your feet and/or hands for a minute or so, or until the area in front of the net has been thoroughly disturbed. Take kicknet samples from the middle and edge of the stream. Kicknets can also be used to sample margins of weed-beds and undercut banks and other habitats. Place the net in roots, stick piles, or in aquatic vegetation and vigorously move the net back and forth for several seconds. At this point, it is best to place all material in the net into a collection jar and add preservative. If organisms are sorted in the field, take care not to overlook any of them. Other collection methods include lifting a rock, stick, etc. from the stream and carefully looking for invertebrates. Remove the organisms carefully with forceps and place them in a jar containing alcohol. In this type of collecting, the movement of the invertebrates will often help you locate them.

Sort macroinvertebrates from other material obtained during the collection process in an area with good light. A magnifying glass and fine-tipped forceps will prove invaluable. Place small portions of the collected material in a white-bottomed plastic or enamel pan. Carefully sort through the material, removing the invertebrates with forceps. Place sorted invertebrates into a jar containing clean preservative, preferably 70 percent alcohol. Continue this process until all samples are sorted. Place labels denoting the collection date, location and collectors in the jars. Use a lead pencil in all labeling.

You can obtain much information about the condition of the invertebrate community and water quality of a stream without

identifying the organisms. Simply by carefully sorting the collection and grouping organisms that look alike, you can determine the number of types present. To sort, use primarily body shape and number of legs and tails; secondary characteristics such as size and color patterns may also be used. If a good variety of types are present, with small numbers of each type observed or collected, the stream probably has good water quality. A poor stream will generally have only a few types, with large numbers of each.

Fish may be collected by a variety of methods, but small- and medium-sized streams are easily surveyed with a minnow seine. (A valid Kentucky fishing license is required to seine). It is important to note that before you can keep collected fish, you must receive permission from the Kentucky Department of Fish and Wildlife Resources in the form of a collection permit. Failure to do so could result in fines, loss of equipment and imprisonment.

Fish sampling in riffles is most easily accomplished by collecting in a five or six square foot area at a time. One or two people should hold the net stationary, at a 45° angle to the water in a downstream direction. Another one or two individuals should move five or six feet above the net, start vigorously disturbing the substrate with their feet, and slowly work toward the net. When the collectors reach the net, it should be lifted from the water and taken to shore. The fish should be identified quickly and returned to the stream unharmed as soon as possible. Specimens from a fish kill which may require laboratory analyses should be wrapped in aluminum foil, placed in a plastic bag, and deep frozen. Macroinvertebrates should also be collected from the net. When seining pools, make short seine hauls, preferably starting near the middle of the stream and working to the bank. Be sure to sample areas containing cover (log piles, undercut banks, weedbeds, etc.).

Preliminary identifications of algae, macroinvertebrates and fish can be made using the Appendices in this manual. Also, additional taxonomic references are listed in the References and Additional Readings section.

Water Sampling Survey

A water sampling survey measures the physical and chemical characteristics of the stream at the time of sampling. However, remember that these samples represent only

one point in time, and they may not tell the whole story. Since these surveys are costly and complex, they are best done by professionals. If the visual and biological surveys indicate the stream is polluted, any of the commercial laboratories found throughout the state can analyze selected chemical parameters of the water.

Collection Equipment

Most freshwater organisms can be collected with the simplest of homemade equipment. A little ingenuity is all that is required. A few pieces of equipment that have proven useful over the years are described below. While all of them can be purchased at a biological supply house, most can be made at home.

Personal Equipment

a) Clothing suitable for field work including rubber boots or tennis shoes, waders, and other waterproof gear.

b) A small case, such as a discarded pocketbook or tobacco pouch outfitted with a pocket lens, pencils, notebook and forceps.

c) Containers suitable for bringing back materials collected. These containers include small jars of assorted sizes with tight-fitting lids, and one or two large jars in which to bring home unsorted material. You will also need a few vials of 70 percent alcohol and some heavy duty plastic bags.

Sampling Equipment

a) Hand screen

Materials - Nylon or Wire Door Screen (1' X 2')
- 2 Wooden Poles (5' - 6')
- Finishing Nails or Staples
- Tinner's Shears

In Figure 8, "S" is a sheet of door screen (1' X 2'). If wire screen is used, the woven edge is put on the bottom. The opposite edge should be folded, leaving no projecting wire-ends. The folded ends of the screen are wrapped around the poles and either nailed or stapled.

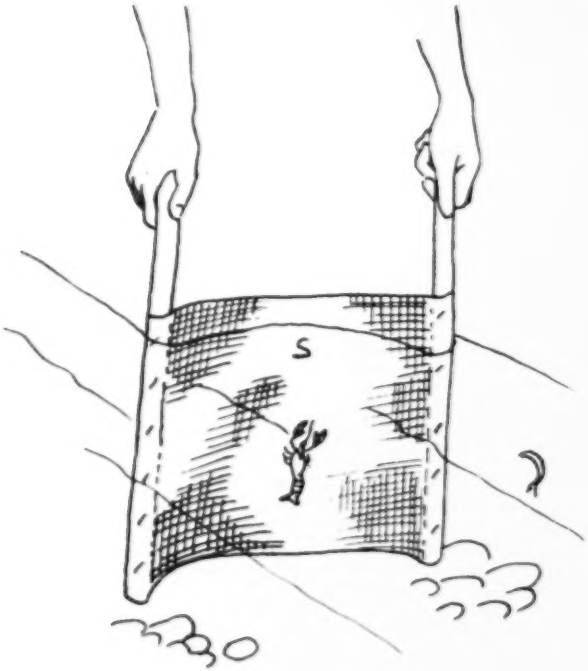

Figure 8. Hand Screen.

b) Observation Pan

An ordinary white enamel or plastic pan can be used for examining a catch.

c) Dip Nets

Aquarium dip nets, sold by most pet stores, are useful for light work around weed beds and along the banks of streams or ponds.

An ordinary kitchen sieve tied to a long handle will serve well as a dip net for light work along stream or pond banks.

Materials - Heavy Gauge Steel Wire
- Wood Pole (5' - 6')
- Thin Wire
- Any meshed fabric (curtains, mosquito netting, etc.)
- Heavy Twine
- Heavy Fabric Strip (4" wide) or duct tape

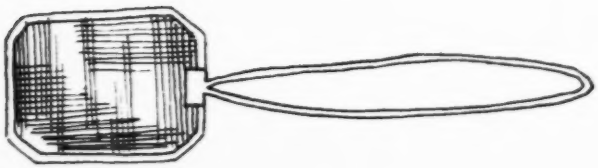

Figure 9. Dip Net Made from Kitchen Sieve.

The frame, made of heavy gauge steel wire, may be circular, semi-circular, triangular or diamond-shaped, about eight inches in diameter (Figure 9). The handle has two grooves at one end, one on each side. Each groove is a different length and each ends in an inch-deep hole. The two loose ends of the wire frame also differ in length to match the grooves in the handle. The tip of each wire is bent at a right angle. The end of the frame can them be fitted into the grooves in the handle and bound in place by wire.

The net bag is made of coarse-meshed material and bound with a heavy fabric around the frame (Figures 10 & 11). Before cutting out the two pieces of netting from which the bag will be made, make sure to measure the frame and then estimate the width of the cloth needed. The two pieces should be stitched together. The strip of four-inch heavy fabric should be folded lengthwise, the edges turned in, and bound to the net bag with the two

open ends coming together above one of the seams. These ends are left open for the insertion of the wire frame.

d) Seines

Minnow seines (6' x 4') can be purchased for a modest price at most bait shops.

A cheap seine can be made by cutting a burlap sack down the sides. Attached the sack to two wooden poles (six feet long) with finishing nails or wire. Add lead weights to the bottom and floats to the top if needed.

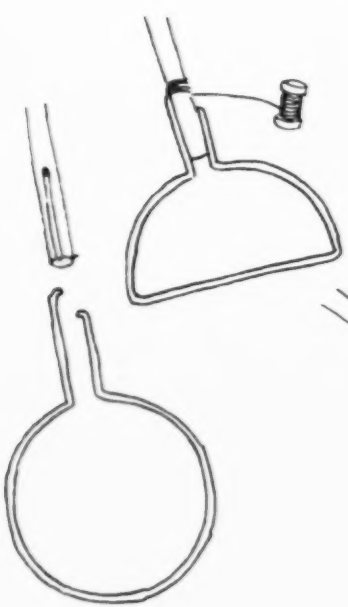

Figure 10. Dip Net Wire Frame Construction.

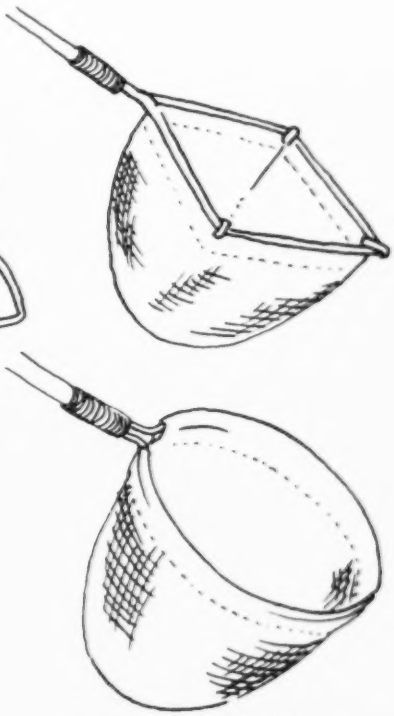

Figure 11. Dip Net With Mesh Net.

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APPENDICES

58

APPENDIX 1 DIAGNOSIS

Can you tell what might be wrong with your stream? Just like diagnosing the cause of a pet's sickness, you can take all the symptoms and signs together and try to determine what might be causing the problem. These tables are to help you know what types of problems might occur in your area and the obvious signs of those problems. Read each table several times, allowing yourself to get a feel for threats to streams. You may even want to take these tables with you the next time you visit your stream.

Table 1. Characteristics of Surrounding Area Draining Into a Stream.

A. **Woodland:** Check for sedimentation (cloudy or muddy water) from erosion caused by logging, road building, mining or any clear cutting.

B. **Farmland (crops, pasture and feedlots):** Check for excessive algal growth (green water or stream clogged with water plants) caused by fertilizers or manure draining into stream. Also watch for sedimentation caused by poor farming practices.

C. **Cities and Towns:** Urban storm sewer runoff can carry with it all sorts of pollution including metals (lead), salts, chemicals and oil. Insect and fish counts may indicate the presence of one of the above, but chemical analysis of the water may be needed to pinpoint the cause.

D. **Industries:** Because of the variety of chemicals produced by industry, the stream should be tested for inorganic (metals), organic (pesticides, phenols, oil, etc.), and toxic substances. Keep an eye out for color changes, excessive algae, odor, absence of animal life such as insects and fish, and fish kills.

E. **Sewage (treatment plants or pipelines):** Look for "organic" pollution indicated by excessive algal growth, white foam or suds from detergents, sludge beds, absence of some species of fish and insects, and/or extreme abundance of others.

F. **Mining:** Check for sedimentation and acid drainage. Acid drainage can be detected by a low pH (below pH 4.0). A yellowish-orange deposit often is present on the bottom due to high iron content of most mine drainage.

G. **Construction:** Land disturbing activities such as development and road building are the leading cause of erosion and sedimentation, so watch for cloudy or muddy water.

H. **Residential:** Lawn fertilizers, detergents used for washing clothes or cars, oil drained from cars, septic tank outflow, and general trash (cans, bottles, etc.) are common forms of residential pollution. Keep an eye open for excessive algae growth, white suds, color sheen on surface (oil), or absence or organisms.

Table 2. Physical Indicators of Water Pollution.

A. **Color of Stream**

1. **Green:** If the stream is noticeably green, this could be an indication of "organic" pollution being released into the stream feeding algae (hence the term algal bloom) and other aquatic plants.

   What to do: Check upstream for possible sewage, fertilizer or livestock run-off areas.

2. **Orange-Red:** Orange to red deposits on stream beds could be caused by acid mine drainage or oil well runoff. The color is due to iron in duch drainages.

What to do: Check upstream for mining or drilling and watch for industrial waste draining into the stream.

3. **Light Brown:** Sediment deposition (muddy or cloudy) caused by erosion.

   What to do: Search upstream for disturbed ground left open to rainfall and subsequent erosion.

4. **Multi-color Reflection:** Indicates oil floating in stream.

   What to do: Check closely upstream for source. Waste oil may have been dumped into the stream by an individual or service station. Overflow may have occured from an oil well operation.

5. **White Deposits Along Banks:** White, crusty deposits along the edge of the stream may indicate salt pollution from oil well operations

   What to do: Search upstream for oil well operations.

6. **Dark reds, purple, blues, blacks:** Indicates organic dye pollution possibly from leather tanning or clothing manufacture.

   What to do: Check closely for upstream source, possibly a point source from an industrial plant.

B. **Stream Odor**

1. **Rotten egg:** Indicates sewage pollution.
2. **Musky Odor:** May indicate presence of untreated sewage, livestock waste, algae or other conditions.
3. **Acrid Smell:** May indicate presence of industrial or pesticide pollution.
4. **Chlorine:** This may mean that a sewage treatment plant or chemical industry is overchlorinating its effluent.

What to do for 1-4: Check upstream for industrial, municipal, or residential waste entering the stream.

C. **Foaming (Suds):** When white and greater than three inches high, generally due to detergents.

What to do: Check upstream for industrial, municipal or residential waste entering the stream.

Table 3. Fish as Biological Indicators of Water Quality.

A. **Erratic Swimming:** Fish swimming near the surface, gasping for air at the surface, or swimming in circles may indicate the presence of toxic substances or low dissolved oxygen.

B. **Disease:** The presence of red sores or white, cottony places on fish indicates the presence of disease. Disease may indicate the presence of toxic substances at levels not great enough to immediately kill the fish.

C. **Absence of Fish:** This may be a strong indication of a badly stressed stream. The cause could be urban run-off, sewage or toxics (inorganic and organic) entering the stream.

What to do for A-C: Chemical analysis of the water may be needed to find the source, but check upstream to see where it begins.

APPENDIX II
Field Data Sheet

River Basin

Collectors

Stream Name

Date

Stream Location

County

Weather Conditions: ☐ Clear ☐ Cloudy ☐ Rain

☐ Other _____

Type of Sampling: ☐ Water ☐ Biological

☐ Bacteriological (include time of collection)

Field Tests:

Temperature (air) _____ Conductivity (mmhos) _____

Temperature (water) _____ pH _____

Dissolved Oxygen (mg/l) _____ Other _____

Water appearance	Stream bed coating	Odor
☐ Scum	☐ Orange to red	☐ Rotten Egg
☐ Foam	☐ Yellowish	☐ Musky
☐ Muddy	☐ Black	☐ Acrid
☐ Milky	☐ Brown	☐ Chlorine
☐ Clear	☐ None	☐ Other
☐ Colored sheen (oily)		☐ None
☐ Brownish		
☐ Other		

1 Habitat:

☐ Pool	☐ Undercut Banks	☐ Log Piles
☐ Riffle	☐ Rock Ledges	☐ Weed Beds
☐ Wetlands	☐ Tree Roots	☐ Large Boulders
☐ Backwaters	☐ Logs or Stumps	☐ Man-made Objects

☐ Other (explain) _____

Field Data Sheet - (continued)

2 Depth: Pool _____ Riffle _____

3 Width: Pool _____ Riffle _____

Stream Cover: Stream is -

- ☐ Fully exposed (0-25% of stream is shaded from the sun)
- ☐ Partially exposed (25-50%)
- ☐ Fully Shaded (75-100%)
- ☐ Partially shaded (50-75%)

Riparian Vegetation:

Trees (%) _____ Plants (%) _____ Exposed (%) _____

Shrubs (%) _____ Root Mats (%) _____ Other (%) _____

Biological Samples:

1 Algae Is the algae located: ☐ Everywhere ☐ In Spots

Is the algae: ☐ Attached to the substrate ☐ Floating

☐ Other (explain) _____

2 Macroinvertebrates

No. of macroinvertebrates _____ No. of different types _____

Kinds of macroinvertebrates collected (crayfish, mayflies, etc.) _____

_____

_____

3 Fish Types of fish observed or collected (bass, sunfish, etc.) _____

_____

_____

4 Other aquatic and semi-aquatic organisms (List):

Amphibians _____

_____

Reptiles _____

_____

Shore Birds _____

_____

Waterfowl _____

_____

Mammals _____

_____

Field Data Sheet - (continued)

Visual Survey Checklist

Land Uses in Watershed:

1 Farming ☐ Pasture/Grazing Land ☐ Crops ☐ Woods

☐ Other (explain) _____

2 Urban Areas ☐ Homes ☐ Factories ☐ Stores

3 Mining ☐ Surface ☐ Deep

4 ☐ Logging

5 ☐ Other (explain) _____

Water Uses:

1 ☐ Drinking Water Supply

2 ☐ Industrial Water Supply

3 Agricultural Water Supply: ☐ Irrigation ☐ Livestock Water

4 Recreation: ☐ Swimming ☐ Fishing

☐ Other (explain) _____

5 Waste Disposal:

Are there any discharge pipes: ☐ yes ☐ no

If so, where are they coming from: ☐ Sewage Treatment Plant

☐ Industry (factory) ☐ Farm Lots ☐ Unknown

☐ Other (explain) _____

Stream Channel Alternations: ☐ Dredging ☐ Channelization

☐ Other (explain) _____

Structures or Barriers in the Stream:

☐ Dams ☐ Bridges ☐ Islands ☐ Waterfalls

☐ Other (explain) _____

Litter: Average number of small and large items

Paper, Small Trash	Cans and Bottles	Tires, Carts, etc.
☐ 0-5	☐ 0-5	☐ 0-5
☐ 5-10	☐ 5-10	☐ 5-10
☐ 10-50	☐ 10-50	☐ 10-50
☐ over 50	☐ over 50	☐ Over 50

Field Data Sheet - (continued)

Verbal Site Description: Give visual description of stream, substrate, banks, riparian zone and adjacent land areas.

Field Data Sheet - (continued)

Map of Sampling Location: List pool-riffle areas, hydraulic structures, (i.e. bridges, dams), areas of physical impacts, point sources, gravel bars, islands, etc. Describe banks, width of riparian zone and adjacent land uses. Show dwellings, businesses, roadways and tributaries, direction of stream flow and a north arrow (N).

APPENDIX III
KEY TO ALGAE and ALGAE-LIKE ORGANISMS IN KENTUCKY*

The following key is a general guide to identifying algae and algae-like organisms found in Kentucky's rivers and streams. To some, the key may appear complicated; however, when you understand how it works, it is quite simple. While reading the key, you will make a series of choices to match the observable traits of the algae. You will be given two alternatives; choose the one that applies to the particular sample. Then proceed as directed by the numbers at the end of the sentences to the next set of alternatives or until an end point is reached.

1a. Algae suspended (free-floating) in the upper few feet of water column; sometimes forming surface scums (blooms); individual plants mostly microscopic (or less than 5 mm (¼") long); typically found in ponds, lakes, slow-moving streams and rivers.
PLANKTON **2**

1b. Algae attached to stream bottom, rocks, submerged logs, vegetation, or other surfaces; individual plants often macroscopic (greater than 5 mm (¼") long); typically found in streams, rivers and lake margins.
PERIPHYTON **20**

* NA indicates that the material is one or more of the following: (1) not algae, (2) "none of the above" not addressed in this guide, (3) identification not possible without microscopic examination, (4) may be attributable to nonbiological causes, (5) you've made a wrong choice earlier in the key and need to reconsider identification choices to this point.

Abbreviations:

(FP) - flowering plants
(BG) - blue-green algae
(G) - green algae
(R) - red algae
(YB) - yellow-brown algae

2a. Plankton accumulating at the water surface, forming blooms (surface scums) and/or individual plants small but visible **3**

2b. Plankton uniformily distributed in the water column; not forming surface scums; individual plants mostly microscopic; water appears green or some other color **12**

3a. Plankton consisting of floating filamentous (stringy) mats, often accumulating near lake shores and in coves, but may cover entire surface of lake or pond; **DISLODGED PERIPHYTON** (*Spirogyra, Cladophora, Hydrodictyon*) **20**

3b. Plankton not forming mats **4**

4a. Individual plants 2-4 mm (1/16-3/16") long, flattened; oval or round, with one or more rootlets under each leaf; plants often abundant and may cover entire lake or pond surface . . . . . **DUCKWEED (FP)** (*Lemma, Spirodela*)

4b. Individual plants smaller (less than 2 mm (1/16") with no roots, or appearing as "chopped grass" in the water **5**

5a. Plankton composed of minute, granular globules, non-motile spheres; 2mm (1/16") or less in diameter . . . . . **WATERMEAL (FP)** (*Wolffia*)

5b. Plankton otherwise **6**

6a. Plankton appearing as "chopped grass" in the water . . . . . ***APHANIZOMENON* (BG)**

6b. Plankton otherwise **7**

7a. Plankton forming surface scums **8**

7b. Plankton not forming surface scums . . . . . **NA**

8a. Scum light green to blue-green, typically found in hardwater lakes during warmer months **9**

8b. Scum dark green, reddish, or some other color **10**

69

9a. Scum consisting of visible particles or irregular shape and size, often thick; rocks at lake margin frequently stained light blue, resembling pastel blue paint ..... ***MICROCYSTIS*** **(BG)**

9b. Scum resembling "pea soup" often thick, individual particles often not apparent; rocks not stained pastel blue ..... **BLUE-GREEN ALGAE** (*Anabaena* and other taxa)

10a. Scum dark green (rarely reddish) ..... ***EUGLENA***

10b. Scum some other color **11**

11a. Scum darkly colored, consisting of loosely associated material, often slimy ..... **DEAD ALGAE or OTHER PLANT MATERIAL**

11b. Scum some other color or not as above ..... **NA**

12a. Water color light green to blue-green **13**

12b. Water some other color **17**

13a. Plankton often consisting of tiny visible particles; color variable (green to blue-green to "pea soup" color) **14**

13b. Plankton particles generally not visible; color light green to grass green **16**

14a. Green, motile (moving) spheres, visible in a glass jar of the water ..... ***VOLVOX*** **(G)**

14b. Plankton particles non-motile, light blue-green to "pea soup" color **15**

15a. Particles appearing as "chopped grass" in the water ..... ***APHANIZOMENON*** **(BG)**

15b. Particles of irregular shape and size ..... **BLUE-GREEN ALGAE** (*Microcystis, Anabaena, etc.*)

16a. Water warm (late spring to early fall) ..... **GREEN ALGAE** and/or other algal taxa or **NA**

16b. Water cool (winter) ..... **NA** (Some limestone waters have a bluish-greenish color due to dissolved substances).

17a. Water yellow-green to yellow-brown ..... **18 also see 19**

17b. Water some other color **19**

18a. Water warm (summer-early fall) ..... **DINOFLAGELLATES**

18b. Water cool (late fall-early spring) ..... **DIATOMS**

19a. Water "tea colored" ..... **DISSOLVED ORGANIC MATTER**

19b. Water darkly colored ..... **LIVE OR DEAD ALGAE OR DISSOLVED SUBSTANCES** (e.g., manganese) or **NA**

20a. In running water, shore lines, or in spray; attached **21**

20b. In standing or very slowly moving water; attached or loosely associated with substrate **53**

21a. Plants grey-green to dark green, with leaflike lobes or joints, or with small (3-8 mm (1/16-3/8") long scalelike "leaves" arranged along a stem ..... **MOSSES**

21b. Plants not as above **22**

22a. Plants white to greyish, pinkish white, filamentous; often forming dense coating over rocks and other surfaces ..... **"SEWAGE FUNGUS"** (actually filamentous bacteria — e.g., *Sphaerotilus*, etc.).

22b. Plants green, olive green or some other color **23**

23a. Water cold; late winter, early spring, or spring-fed streams **24**

23b. Water cool to warm, late spring, summer or fall **40**

24a. Algal mats filamentous; individual filaments visible or invisible **25**

24b. Algal mass not filamentous; plants visible or invisible **36**

25a. Algal mass a felt-like mat **26**

25b. Algal mass not a felt-like mat **27**

26a. Algal filaments visible; yellow-green to grass green; mats thick, often coarse; difficult to separate .... ***VAUCHERIA*** **(YB)**

26b. Algal filaments invisible; dark green to black; mats thin, velvety, easy to separate ..... **BLUE-GREEN ALGAE** (*Oscillatoria, Lyngbya, Phormidium, Schizothrix*)

27a. Plants not branched **28**

27b. Plants branched (often bushy) **30**

28a. Plants short (less than 25 mm (1") long), thin, bright green, tolerant to acid mine drainage but present in many streams ..... ***ULOTHRIX*** **(G)**

28b. Plants not as above **29**

29a. Plants longer (greater than 25 mm (1") long), thicker, olive green to black; stiff, cartilagenous ..... ***LEMANEA*** **(R)**

29b. Plants not as above ..... **NA**

30a. Plants embedded in a jelly-like mass **31**

30b. Plants not gelatinous; coarse; often in very swift waters; green to brownish-green; forming long, bushy masses in nutrient enriched streams and lakes .. ***CLADOPHORA*** **(G)**

31a. Plants olive green to dark reddish-purple **32**

31b. Plants brillant green **33**

32a. Plants compact, slippery, with abundant gelantinous mucilage; frequently found in springs or in the outflow from them ..... ***BATRACHOSPERMUM*** **(R)**

32b. Plants elongated, up to 50 cm (20") or more long, 2-3 mm (1/16") wide, rubbery texture ..... ***THOREA*** **(R)**

33a. Gelatinous mass soft, indefinite, lateral branches long ..... ***STIGEOCLONIUM*** **(G)**

33b. Gelatinous mass definite, watery or rubbery, branches short, lateral or otherwise **34**

34a. Gelatinous mass watery, lateral branches short and at right angles to main axis, beaded appearance, found only in clear, cool running water ..... ***DRAPARNALDIA* (G)**

34b. Plants not as above **35**

35a. Gelantinous mass rubbery; branches radiate from base and are repeatedly branched throughout; branches with tough gelatinous envelope, adjoining branches often fused; also found in standing water .. .. ***CHAETOPHORA* (G)**

35b. Plants not as above ..... **NA**

36a. Colony golden-brown to dark brown, gelatinous; rocks slick ..... **DIATOMS**

36b. Colony green, gelatinous, with definite shape .. **37**

37a. Freshwater streams and lakes **38**

37b. Oil brine streams or water with high salt content **39**

38a. Colony delicate, readily disintegrating when handled; colony a hollow sac or tube, attached but held vertically in the water by means of an air bubble ..... ***TETRASPORA* (G)**

38b. Colony otherwise ..... **NA**

39a. Colony firm, tubular, convoluted; "like green intestines" ..... ***ENTEROMORPHA* (G)**

39b. Colony otherwise ..... **NA**

40a. Plants grey-green to dark green with leaflike lobes or joints, or with small (3-8 mm (1/16-3/8") long) scalelike "leaves" arranged along a "stem" .... **MOSSES**

40b. Plants not as above **41**

41a. Plants white to greyish, pinkish-white, filamentous, often forming a dense cottony coating over the stream bottom ..... **"SEWAGE FUNGUS" (See 22)**

41b. Plants green or some other color **42**

42a. "Plants" red or rust colored, loosely associated with stream bottom or rocks, with an indefinite shape; common in shale/sandstone regions especially in coal mining areas ..... **IRON HYDROXIDE FLOC** (not algae)

42b. Plants not rust colored **43**

43a. Algae filamentous, branched or not branched .. **44**

43b. Algal moss not filamentous **50**

44a. Filaments branched **45**

44b. Filaments not branched **48**

45a. Algal mass a felt-like mat (See 26) ..... ***VAUCHERIA*** **(YB)**

45b. Algal mass not felt-like; typically in turbulent water **46**

46a. Algal mass bushy, coarse; dark green to brownish-green ..... ***CLADOPHORA*** **(G)**

46b. Algal mass not as above **47**

47a. Algal mass slimy, bright green ..... ***STIGEOCLONIUM*** **(G) (See 33)**

47b. Algal mass not as above ..... **NA**

48a. Filaments short (1-6"), nodulose, dark olive green to black, in turbulent water ..... ***LEMANEA*** **(R)**

48b. Filaments not nodulose, green **49**

49a. Filaments generally long (to 2 feet), silky, green; algal mass tough ..... ***RHIZOCLONIUM*** **(G)**

49b. Filaments not as above ..... **NA**

50a. Colonies "shot-like", globular, olive green to black; on rocks ..... ***NOSTOC*** **(BG)**

50b. Colony not as above ..... **NA**

51a. Colony green to light green, tough, rubbery or delicate **52**

51b. Colony not as above ..... **NA**

52a. Colony gelantinous, rubbery; branches radiate from base and are repeatedly branched throughout; adjoining branches often fused; less than 15 mm (½") long ..... ***CHAETOPHORA*** **(G)**

52b. Colony delicate, greater than 15 mm (½") long; readily disintegrating when handled; colony a hollow sac or tube; attached, but held vertically in the water by means of an air bubble..... ***TETRASPORA*** **(G)**

53a. Plants grey-green to dark green with leaflike lobes or joints, or with small (3-8 mm (1/16-3/8") long), scalelike "leaves" arranged along a "stem" ..... **MOSSES**

53b. Plants not as above **54**

54a. Plants white to greyish, pinkish-white, filamentous, often forming a dense, cottony coating over the stream bottom ..... **"SEWAGE FUNGUS" (See 22)**

54b. Plants some other color **55**

55a. "Plants" red or rust colored, loosely associated with stream bottom or rocks, with an indefinite shape; common in shale/sandstone regions, especially in coal mining areas ..... **IRON HYDROXIDE FLOC** (not algae)

55b. Plants not rust colored **56**

56a. Cold water; late winter or early spring **57**

56b. Cool to warm water; late spring, summer, fall **63**

57a. Algal filaments branched, not forming mats **58**

57b. Algal filaments not branched, forming mats or attached to various surfaces **59**

58a. Plants tree-like, dark green to grey-green, attached to bottom; typically in ponds and lakes ..... ***STONEWORTS*** (*Chara, Nitella*)

58b. Plants not as above ..... **NA**

59a. Algae attached to dead sticks, submerged wood, weeds and grass stems ..... ***OEDOGONIUM*** **(G)**

59b. Algae loosely associated with stream or lake bottom, not attached **60**

60a. Woodland pools, leaf litter bottoms, shaded ..... ***TRIBONEMA*** **(YB)**

60b. Open ponds, lake margins, pools; exposed to sunlight **61**

61a. Plants often forming mats, free-floating; brilliant green to light green **62**

61b. Plants not as above ..... **NA**

62a. Brilliant green, slippery, ends of mass curling when held aloft; common in limestone areas ..... ***SPIROGYRA*** **(G)**

62b. Bright green to light green, less slippery; ends of mass not distinctly curling; relatively rare in limestone areas but common in shale/sandstone areas ..... ***MOUGEOTIA*** **(G) or** ***ZYGNEMA*** **(G)**

63a. Algae not filamentous, colonies slimy, membranaceous, often occurring on mud; or globular, gelantinous colonies **64**

63b. Algae filamentous, branched or unbranched ... **68**

64a. Globular, tough gelantinous colonies, olive green to black; individual plants visible ..... ***NOSTOC*** **(BG)**

64b. Slimy, membranaceous colonies, individual plants invisible, often on mud; also found in springs and seeps **65**

65a. Colonies golden to brown color ..... **DIATOMS**

65b. Colonies some other color **66**

66a. Colonies blue-green, olive or black ..... **BLUE-GREEN ALGAE**
(*Oscillatori, Schizothrix, Phormidium,* etc.)

66b. Colonies some other color **67**

67a. Algal mass a tough, membranaceous paper-like sheet; green to olive green ..... **BLUE-GREEN ALGAE** (e.g., *Lyngbya*)

67b. Algae not as above ..... **NA**

68a. Plants tree-like; grey-green to dark green; growing on bottom mud, submerged from a few inches to 30 feet ..... **STONEWORTS** (*Chara, Nitella*)

68b. Plants not tree-like; not growing from bottom mud **69**

69a. Filaments unbranched; attached to submerged wood, sticks, weeds and grass stems ..... ***OEDOGONIUM*** **(G)**

69b. Filaments not attached to submerged wood ... **70**

70a. Filaments forming a tubular net or modified into gelatinous colonies or flat green discs **71**

70b. Filaments not as above; coarse or silky; branched or unbranched **74**

71a. Algal mass forming a tubular net; greater than 15 mm (½") long ..... ***HYDRODICTYON*** **(G)**

71b. Algal mass not forming nets **72**

72a. Algal mass a branched gelatinous colony or a flat green disc **73**

72b. Algal mass not as above ..... **NA**

73a. Small, rubbery hemispherical or branched gelatinous colonies; light green ..... ***CHAETOPHORA*** **(G)**

73b. Flat, darker green discs, often attached to dead cattail or water lily leaves ..... ***COLEOCHAETE*** **(G)**

74a. Filaments coarse, branched, not slippery **75**

74b. Filaments silky, unbranched, slippery **77**

75a. Filaments with well-defined, scattered dark swollen areas ..... ***PITHOPHORA*** **(G)**

75b. Filaments without such areas **76**

76a. Filaments bushy, dark green to brownish-green .. .. ***CLADOPHORA*** **(G) (See 30)**

76b. Filaments not as above ..... **NA**

77a. Algal mass bright green to yellowish color **78**

77b. Algal mass some other color **79**

78a. Bright green to yellowish, very slippery if green; ends of mass curling if held aloft, common in limestone areas ..... ***SPIROGYRA*** **(G)**

78b. Green to yellowish, only slightly slippery; ends of mass not curling; relatively rare in limestone areas but common in shale/sandstone areas .... ***MOUGEOTIA*** **(G)** or ***ZYGNEMA*** **(G)**

79a. Algal mass black, slimy ..... **DEAD ALGAE**

79b. Algal mass some other color ..... **NA**

78

APPENDIX IV
KEY TO AQUATIC MACROINVERTEBRATES IN KENTUCKY

This key, obtained from Standard Methods, was developed to be used with the discussion on benthic macroinvertebrates. Follow the same instructions given for the key to Algae to determine the different orders of macroinvertebrates you may find along Kentucky's rivers and streams. Practice with the key. Do not let it overwhelm you. It will be helpful if you use the key in conjunction with an entomology (the study of insects) text. This will clarify difficult or confusing terminology and illustrate body parts.

1a. Body bilaterally symmetrical (with right and left sides, but may be superficially coiled into a spiral); animal usually not attached but may live inside an attached cocoon or case, or crawl about; usually solitary **4**

1b. Symmetry not bilateral **2**

2a. Body typically radially symmetrical. Animals with soft, smooth bodies and tentacles around mouth; no anus. Solitary or colonial. **HYDRAS, JELLYFISHES** (Coelenterata) ..... *

2b. Body or colony non-symmetrical **3**

3a. Body mass generally porous; not a colony, sometimes finger or antler-like. Freshwater representatives generally are fragile, colored green or brown. **SPONGES** (Porifera) ..... *

3b. Colony a jelly-like mass, a network of branching tubes, a plant-like tuft, or a lacy, limy crust or mass **MOSS ANIMALS** (Bryozoa) ..... *

4a. Animal living within a hard shell, soft body (Mollusca) **10**

4b. Animals without a shell **5**

5a. Jointed legs present, may not be functional. Body may be hard or soft **11**

5b. Jointed legs absent, body covering mostly soft, animal pliable (a hardened head capsule may be present) **6**

6a. Body banded by rings or creases at regular intervals, dividing it into many small segments, much wider than long **7**

6b. Segments present or absent; if present, not much wider than they are long **8**

7a. Body with suction disc at one or both ends; in length usually less than 10 times its width. **LEECHES** (Annelida, Hirudinea) . . . . . *

7b. Body without suction discs, in length usually more than 10 times its width; hairs or bristles often evident. **SEGMENTED WORMS** (Annelida) . . . . . *

8a. Body unsegmented, long and slender, appearing smooth, evenly tapered to a fine point at one end. **ROUNDWORM** (Nematoda) . . . . . *

8b. Body otherwise **9**

9a. Body flat, elongate, or oblong; unsegmented head is spade-shaped. Pigmented spots on top of head often give the animal a cross-eyed appearance. **FLATWORMS** (Turbellaria) . . . . . *

9b. Body segmented, cylindrical, oblong, or capsule-like; may or may not have a head capsule and thick fleshy knobs on underside. Larvae of **FLIES** and **MIDGES** (Diptera) . . . . . *

10a. Shell consisting of two hinged halves. **BIVALVES** (Pelecypoda) . . . . . *

10b. Shell entire, usually spiral but may be "coolie hat" shaped, **SNAILS** (Gastropoda) . . . . . *

11a. Body with functional legs **12**

11b. Body without functional legs, mummy or capsule-like, living in a cocoon. **PUPAE** (Insecta) . . . . . *

12a. Body with three pairs of legs. **LARVAE, NYMPHS, AND SOME ADULTS** (Insecta) 15

12b. Body compact, spider-like, with four conspicuous pairs of legs (two other pairs of appendages present). **WATER MITES** (Acari) . . . . . *

12c. Body with at least five conspicuous pairs of legs. **CRUSTACEANS** (Crustacea) 13

13a. Sides of body compressed or not, but never flattened horizontally 14

13b. Body flattened horizontally with three or more joints. **SOW BUG** (Isopoda) . . . . . *

14a. Eyes on stalks. Pincers on first pair of legs strong and large; other legs stout, cylindrical, and used for walking. **CRAYFISH** (Decapoda) . . . . . *

14b. Eyes, if present, only seen as spots on sides of head **SCUDS** (Amphipoda) . . . . . *

15a. Animal flea-like, with a forked projecting appendage on the underside. **SPRINGTAILS** (Collembola) . . . *

15b. Animal otherwise 16

16a. Body ending in long segmented filaments 17

16b. Long filaments absent or, if present, not segmented 18

17a. Two tail filaments, legs ending in two claws **STONEFLIES** (Plecoptera) . . . . . *

17b. Three tail filaments (with few exceptions); middle filament may be slightly smaller than laterals or appear absent, legs ending in one claw. **MAYFLIES** (Ephemeroptera) . . . . . *

18a. Back of body covered with hard wing covers, a pair of thin, sheet-like wings underneath the covers. **ADULT BEETLES** (Coleoptera) . . . . . *

18b. Back without hard wing covers 19

19a. Body with exposed membranous wing pads on back **20**

19b. Body without membranous wings or wing pads (larvae) **22**

20a. Membranous wings present; held flat and in a V-shape on back. Mouth parts formed into a long, sharply pointed beak folded underneath body. **TRUE BUGS** (Hemiptera) ..... *

20b. Membranous wings absent, wing pads present. Mouth parts formed into an extendable, scoop-like mask that covers face. (Odonata) **21**

21a. Body ending in three oblong, fan-like plates. **DAMSELFLIES** (Zygoptera) ..... *

21b. Fan-like plates absent. **DRAGONFLIES** (Anisoptera) ..... *

22a. Mouth parts formed into slender curved rods nearly half as long as body (less than 100 mm). **SPONGILLA FLIES** (Neuroptera) ..... *

22b. Mouth parts adapted for biting or chewing **23**

23a. Body with five paired knobs on underside of abdominal segments, legs on first three segments short and stubby. Often found on lily pads. **AQUATIC MOTHS** (Lepidoptera) ..... *

23b. Body without paired knobs on underside of abdomen **24**

24a. Sides of each abdominal segment with a slender, tapering process **25**

24b. Sides of each abdominal segment without a tapering process, but may have hair-like or tubular processes **26**

25a. Body ending in a pair or hook-bearing fleshy legs or in a single tapering filament. **HELLGRAMMITES** and relatives (Megaloptera) ..... *

25b. Body otherwise. **BEETLES** (Coleoptera) ..... *

26a. Body covering mostly hard; knobs, hair-like processes, or other special ornamentation may be present on back, or else body is entirely soft except for a hardened head capsule. **BEETLES** (Coleoptera) . . . . . *

26b. Most of body soft except for a hardened head capsule and with one to three hard plates on the back of first body segments; tubular processes may be present on sides of the body in various arrangements. Body may end in pair of hook-bearing legs. Most larvae living in portable cases made of bits of sticks, leaves, or sand or in attached fibrous cases. **CADDISFLIES** (Trichoptera) . . . . . *

APPENDIX V
KEY TO THE FAMILIES OF FISHES IN KENTUCKY

Of the three classes of fishes, two are found in Kentucky. These are the Agnatha or jawless fishes, such as lampreys, and the Osteichthyes or bony fishes. (The third class, Chondrichthyes or cartilaginous-fishes, includes sharks and rays and is not found in the state).

In order to identify a fish, it is necessary to know something about its structure, especially those parts used in classification. Figure 12 shows the parts of a fish as referred to in the key. Other terms used in the key may be found in the Glossary.

Starting with the first pair of terms (couplet) choose which statement fits the fish that you wish to identify. If the statement that you choose ends with a number, go to that number, read the couplet, and continue as directed until you reach a statement that refers to a figure or family name.

Following the key are pictures of representatives of all the fish families. The numbers on the pictures refer to the number of the statement that identifies that family.

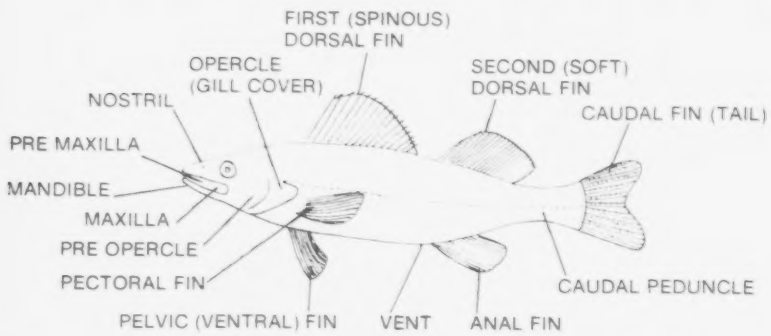


Figure 12. Diagrammatic Outline of a Fish.

Section I. Fishes Without Spines in Fins. (Note: Trout-perch and silversides have weak spines which are easily mistaken for soft rays. They are in Section II).

1a. Jaws and paired fins absent. Mouth a sucking disc. Seven gill openings on each side. Body snakelike ..... **Lamprey Family**

1b. Jaws and paired fins present, gills covered by bony flap (opercle) **2**

2a. Eyes small or absent. Vent (anus) in throat. Small fishes, often colorless ..... **Cavefish Family**

2b. Eyes normal. Vent abdominal **3**

3a. Body shape snake-like. Pelvic fins absent ..... **Eel Family**

3b. Body shape fish-like. Usually 2 pairs of paired fins **4**

4a. Snout long and paddle-like. Body without scales ..... **Paddlefish Family**

4b. Snout not long and paddle-like. Body with scales or plates **5**

5a. Snout long and cylindrical with numerous sharp teeth. Body covered with hard, diamond-shaped scales. Dorsal fin short, near caudal fin ..... **Gar Family**

5b. Snout not long and cylindrical **6**

6a. Body naked except for 5 rows of bony plates. Snout protruding forward of ventral mouth, lower side of head with 4 barbels ..... **Sturgeon Family**

6b. Body with scales, snout not as above **7**

7a. Dorsal fin very long, covering most of back almost to caudal fin. Mouth large, head covered with bony plates ..... **Bowfin Family**

7b. Dorsal fin not as above **8**

8a. Snout duck-bill shaped, with strong sharp teeth ..... **Pike Family**

8b. Snout not as above **9**

9a. Adipose fin (see Glossary) present... **Trout Family**

9b. Adipose fin absent **10**

10a. Mouth with thick lips (suckerlike) .. **Sucker Family**

10b. Mouth not as above **11**

11a. Midline of belly with strong spiny scutes (scales) ..... **Herring Family**

11b. Midline of belly with normal scales **12**

12a. Eye large. Body greatly flattened, anal fin long (more than 15 rays) ..... **Mooneye Family**

12b. Eye normal, rarely large. Body usually rounder. Anal fin shorter (less than 15 rays) **13**

13a. Caudal fin more or less forked ... **Minnow Family**

13b. Caudal fin rounded or square. Mouth superior (lower jaw longer than upper) **14**

14a. No groove between upper lip and tip of snout (non-protractile) ..... **Mudminnow Family**

14b. Upper lip separated from snout by deep groove (protractile) **15**

15a. Anal fin similar in both sexes. Egg layers ..... **Killifish Family**

15b. Anal fin of male modified into copulatory organ. Bear living young ..... **Livebearer Family**

Section II. Fishes With One or More Spines in Dorsal, and/or Pectoral Fins.

16a. Body naked. Dorsal and pectoral fins each with single strong spine. Four pairs of barbels present ..... **Catfish Family**

16b. Body usually scaled. Never 4 pairs of barbels . . **17**

17a. Body naked. Dorsal fin with 6 to 9 spines. No barbels . . . . . **Sculpin Family**

17b. Body with scales **18**

18a. Dorsal and anal fins each with single strong spine . . . . . **Minnow Family (Carp)**

18b. Dorsal fin with more than one spine **19**

19a. A small adipose fin present. Dorsal fin with two weak spines. Small (2 to 4 inches long) . . . . . **Trout-Perch Family**

19b. No adipose fine. Size small or large **21**

20a. Vent in throat region, in front of pectoral fins (except in young) . . . . . **Pirate Perch Family**

20b. Anus in normal position **21**

21a. Small slender fish with pointed beak. Two well-separated dorsal fins, first with weak spines. Anal fin long (20-25 rays) . . . . . **Silverside Family**

21b. Not as above **22**

22a. Anal fin with 1 or 2 spines **23**

22b. Anal fin with 3 or more spines **23**

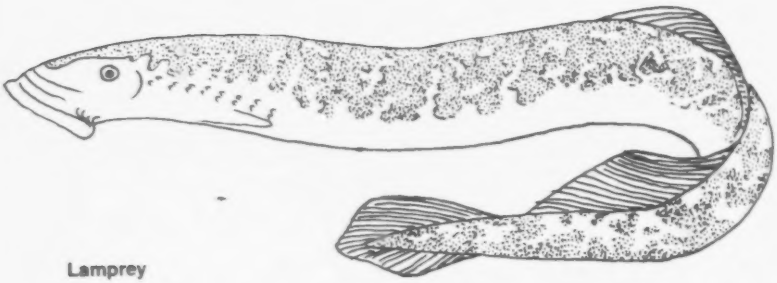
23a. Lateral line continuing across caudal fin . . . . . **Drum Family**

23b. Lateral line not continuing across caudal fin **24**

24a. Spinous and soft dorsal fins entirely separate or only slightly joined. Opercular flap with distinct spine . . . . . **Temperate Bass Family**

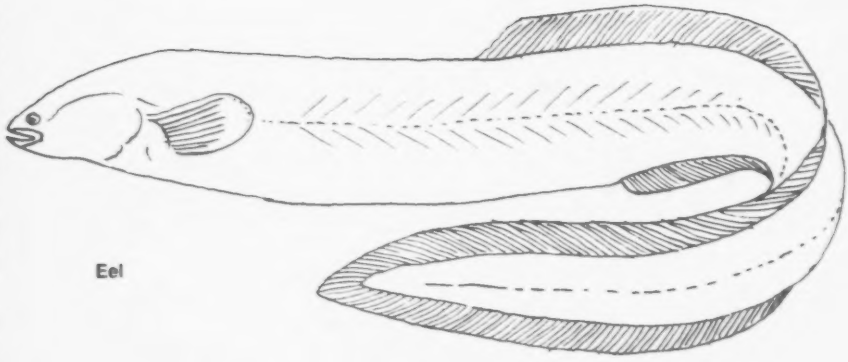
24b. Spinous and soft dorsal continous, sometimes with deep notch. Opercular flap without spine . . . . . **Sunfish (and Black Bass) Family**

1. a. Lamprey Family



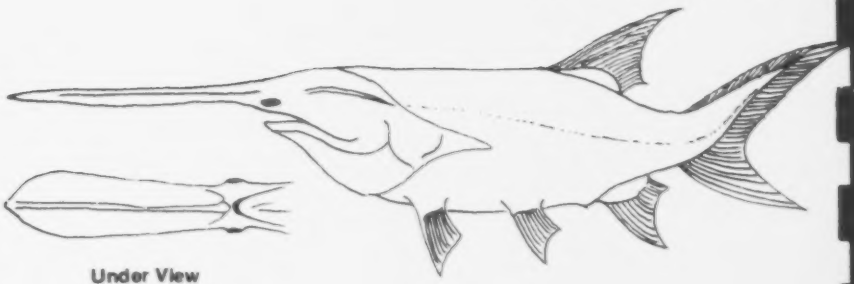
Lamprey

3. a. Eel Family



Eel

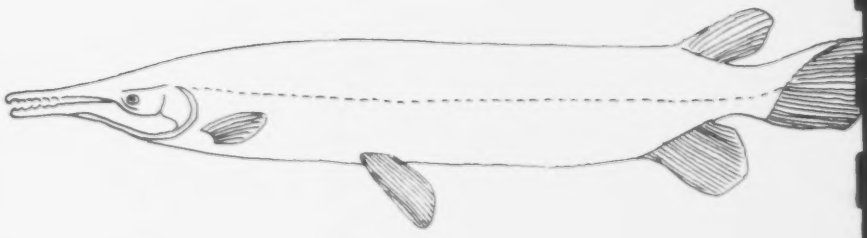
4 a. Paddle Fish Family



Under View

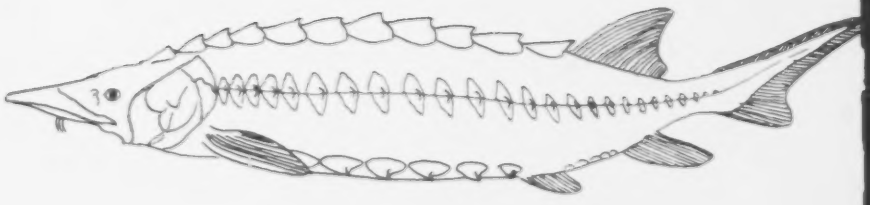
Paddle Fish

5 a. Gar Family



Gar

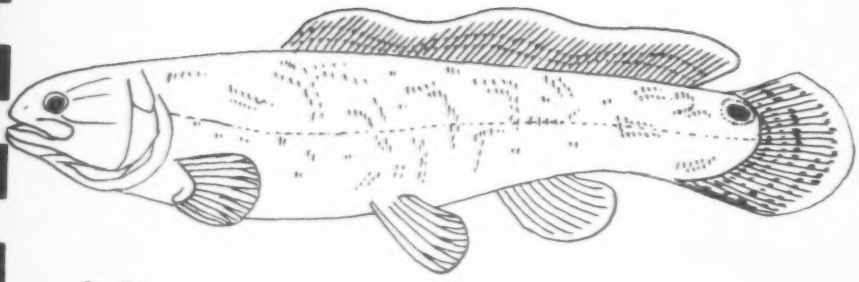
6 a. Sturgeon Family



Sturgeon

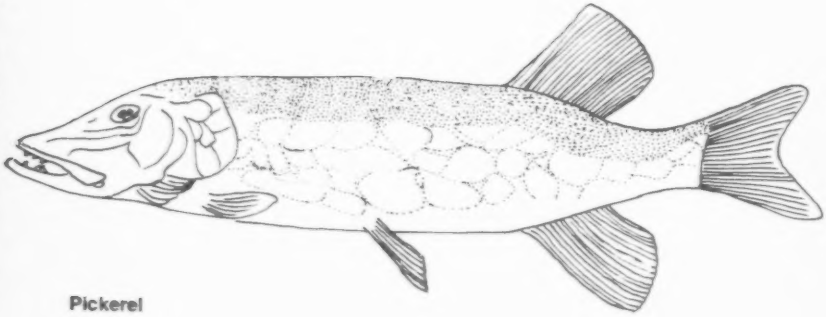
89

7. a. Bowfin Family



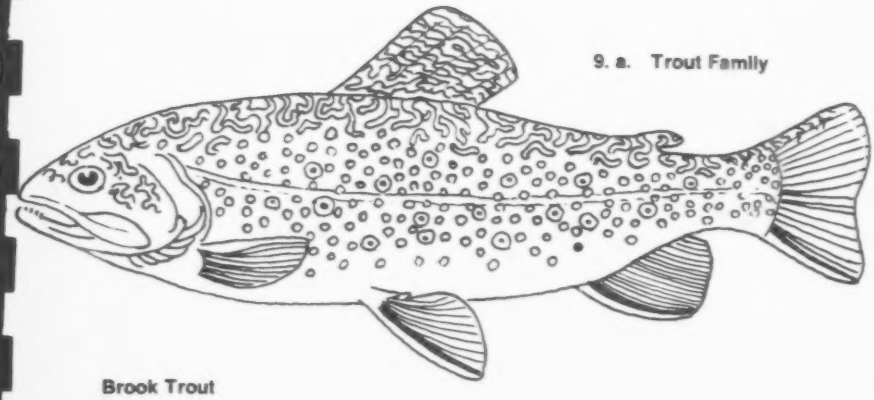
Bowfin

8. a. Pike Family



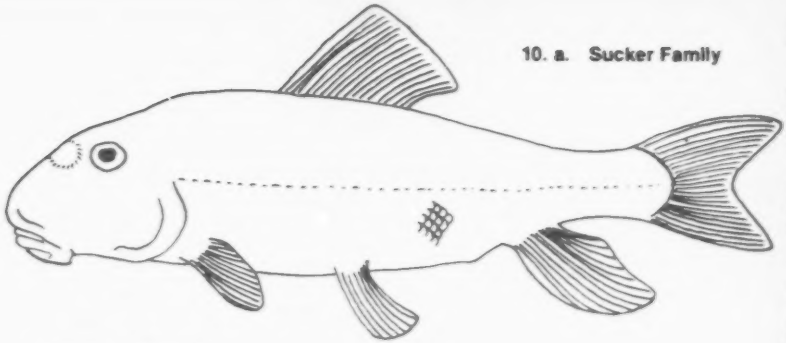
Pickerel

9. a. Trout Family



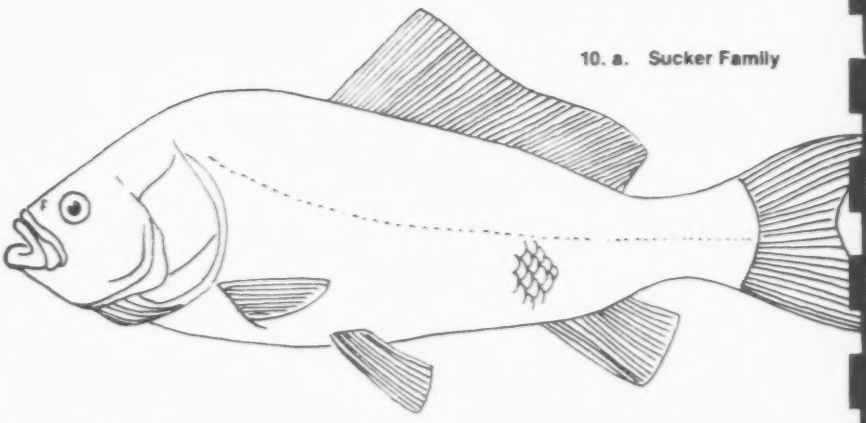
Brook Trout

10. a. Sucker Family



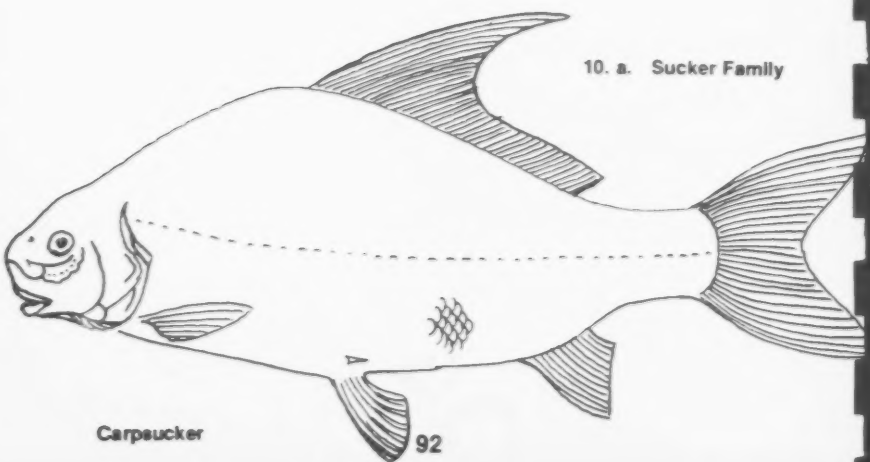
Common Sucker

10. a. Sucker Family



Buffalo

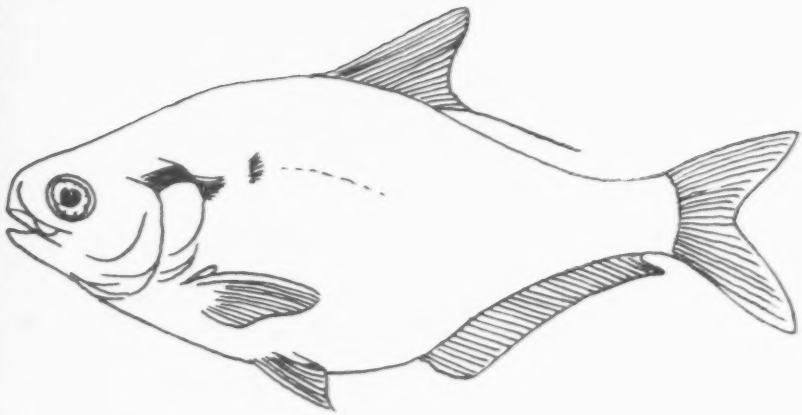
10. a. Sucker Family



Carpsucker

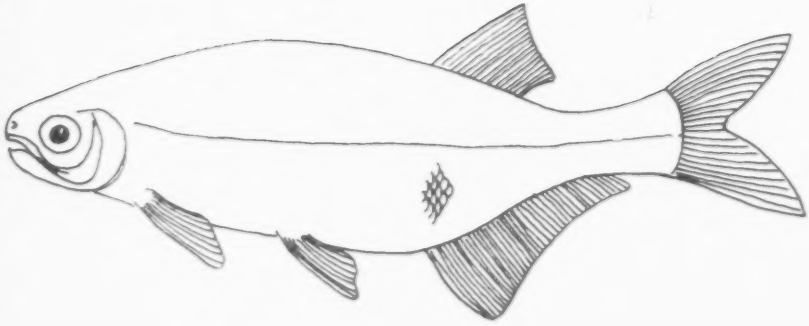
92

11. a. Herring Family



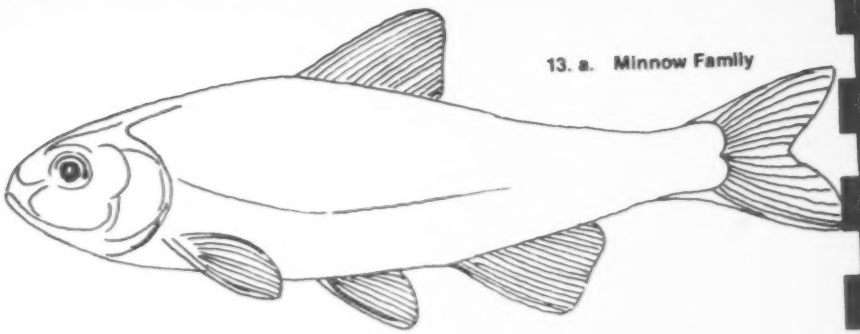
Gizzard Shad

12. a. Mooneye Family



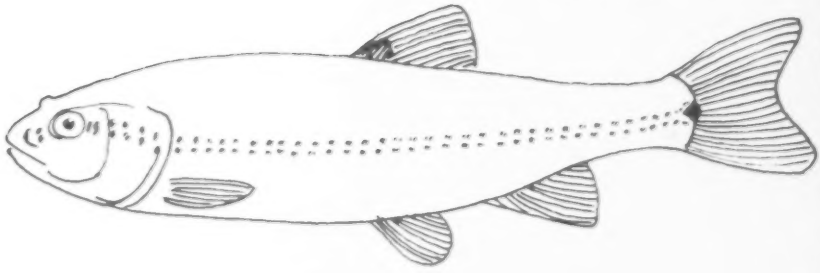
Mooneye

13. a. Minnow Family



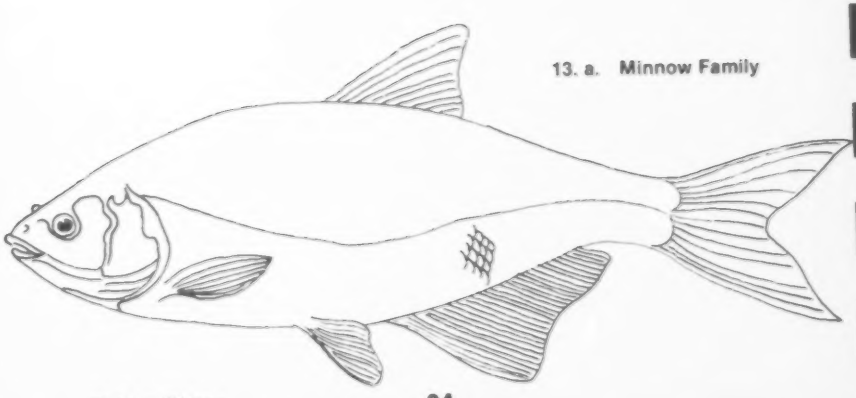
Common Shiner

13. a. Minnow Family



Creek Chub

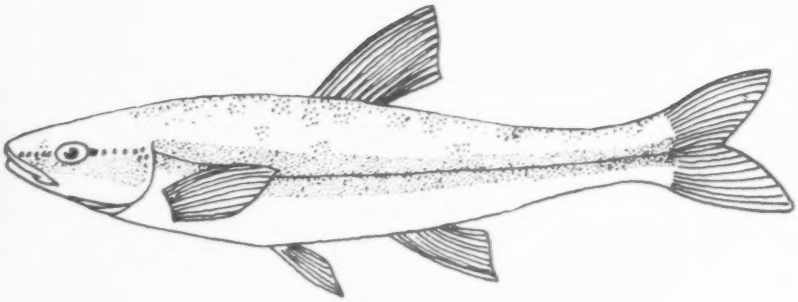
13. a. Minnow Family



Golden Shiner

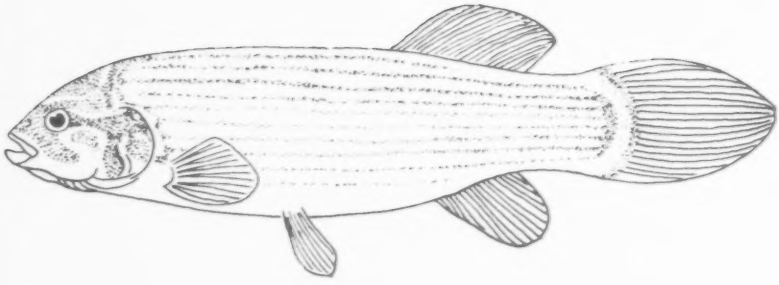
94

13. a. Minnow Family



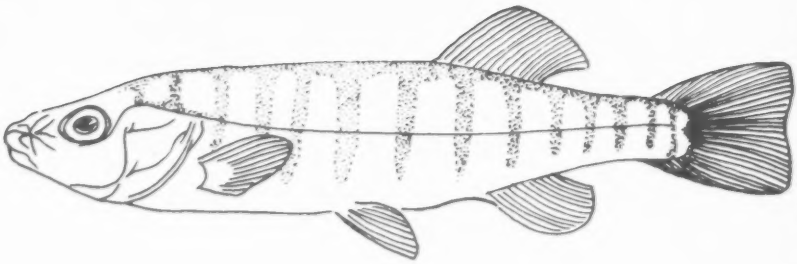
Black-Nosed Dace

14. a. Mud Minnow Family



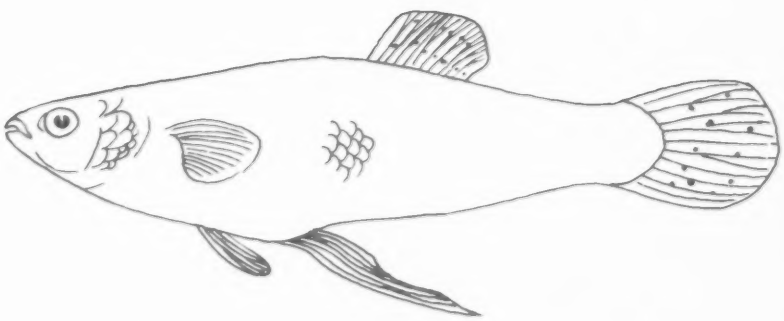
Mud-Minnow

15. a. Killifish Family



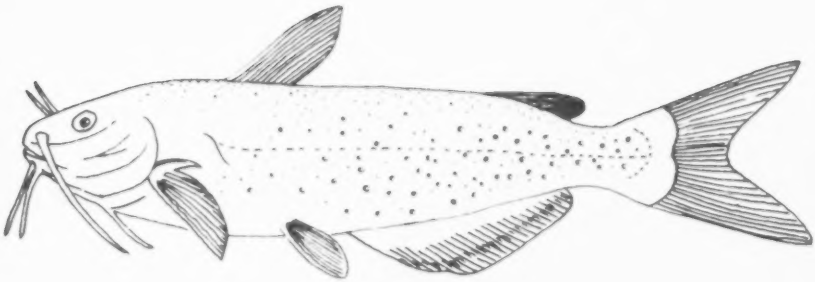
Banded Killifish

15. b. Livebearer Family



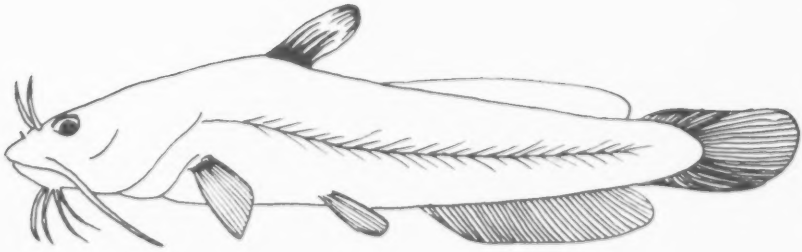
Mosquito Fish

16. a. Catfish Family



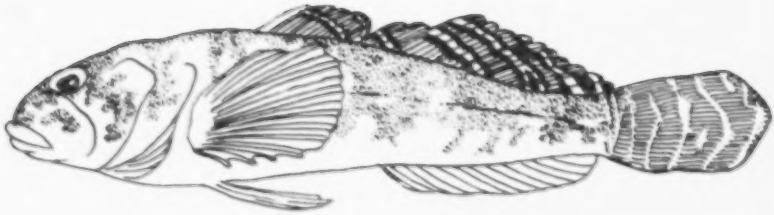
Channel Catfish

16.a. Catfish Family



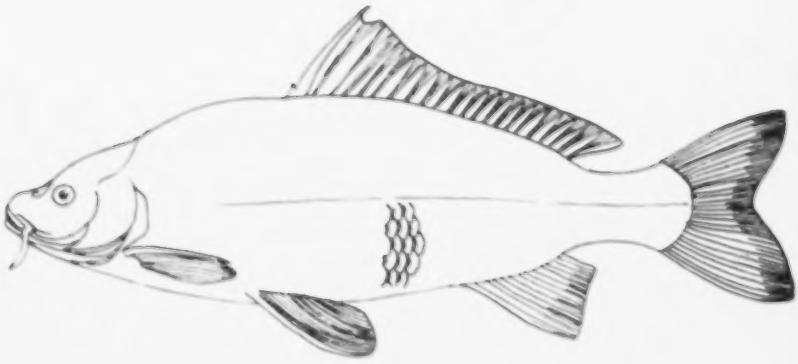
Stonecat

17. a. Sculpin Family



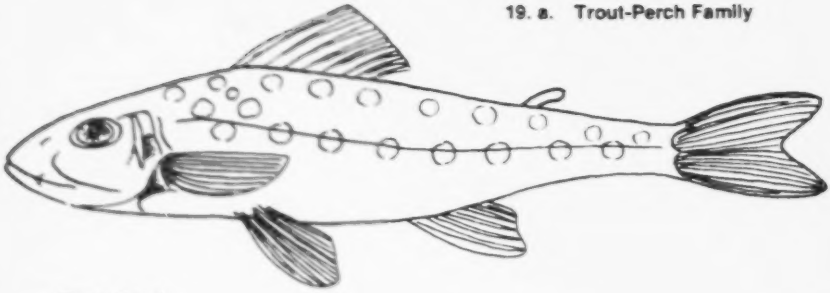
Sculpin

18. a. Minnow Family



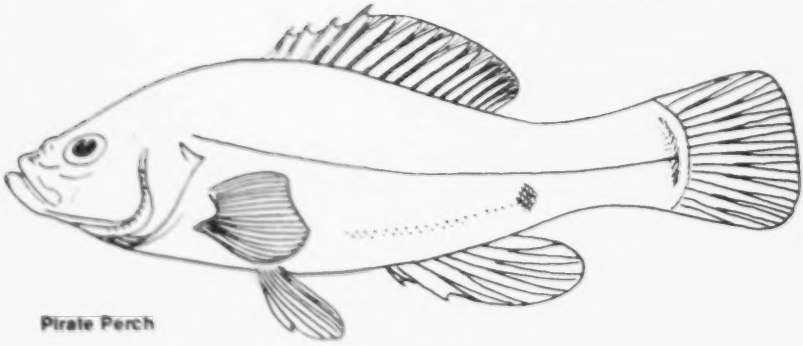
Carp

19. a. Trout-Perch Family



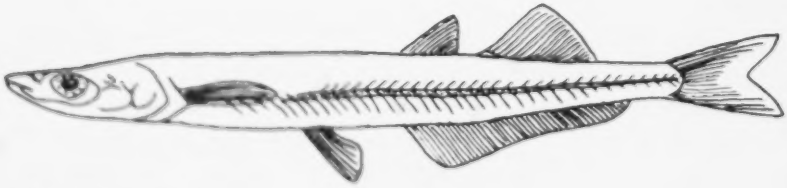
Trout-Perch

20. a. Pirate Perch Family



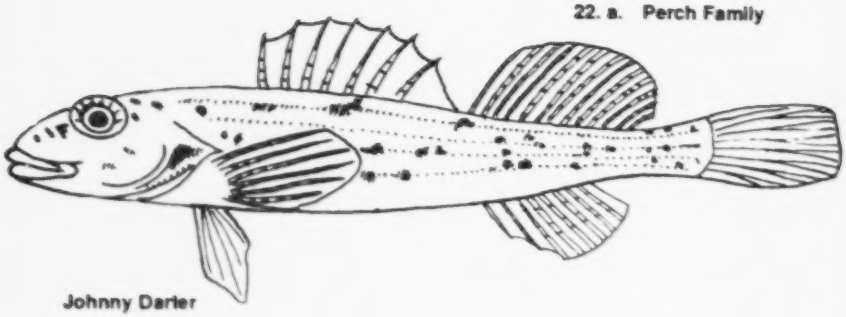
Pirate Perch

21. a. Silverside Family



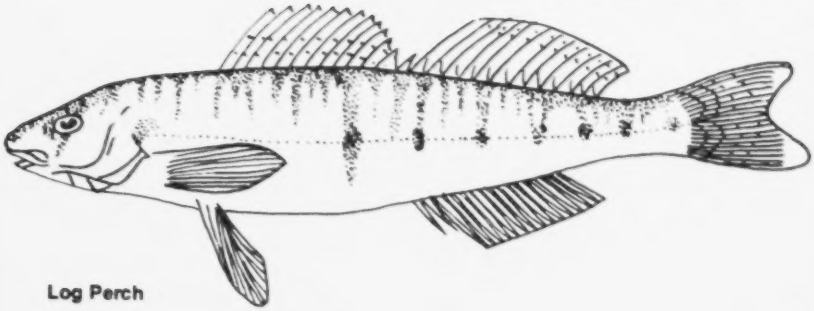
Brook Silverside

22. a. Perch Family



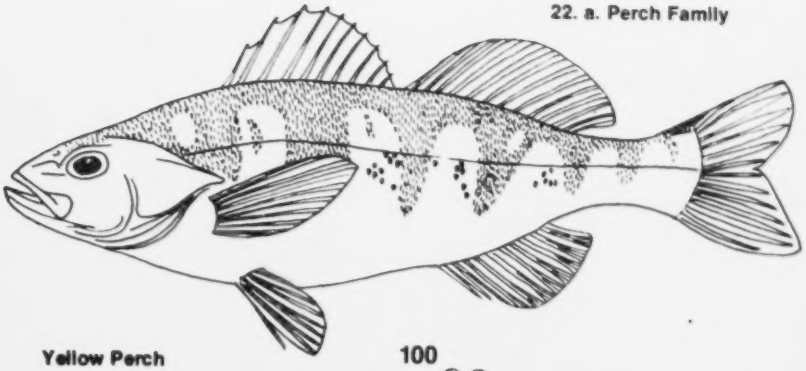
Johnny Darter

22. a. Perch Family



Log Perch

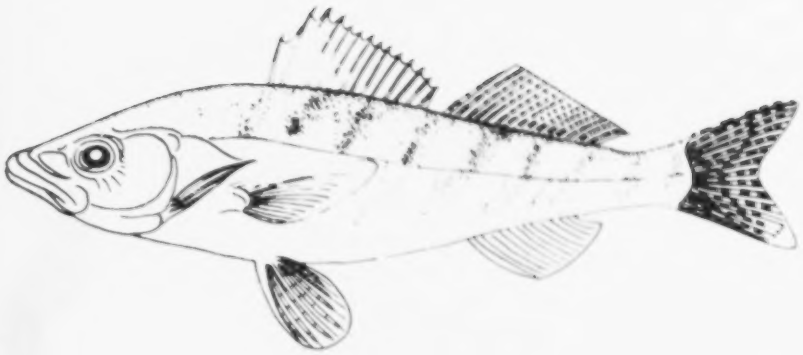
22. a. Perch Family



Yellow Perch

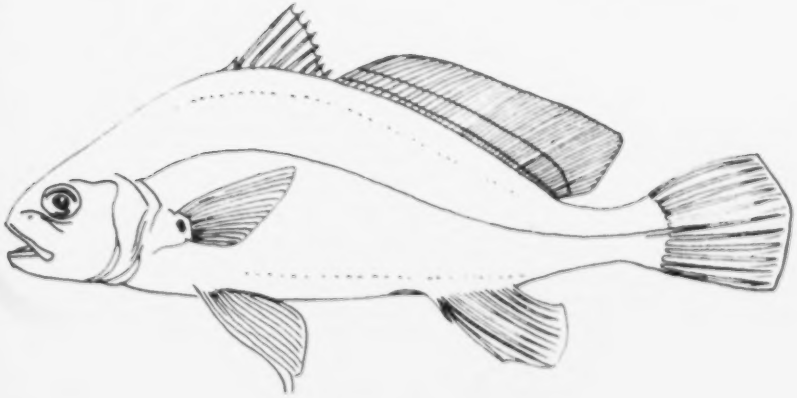
100

22. a. Perch Family

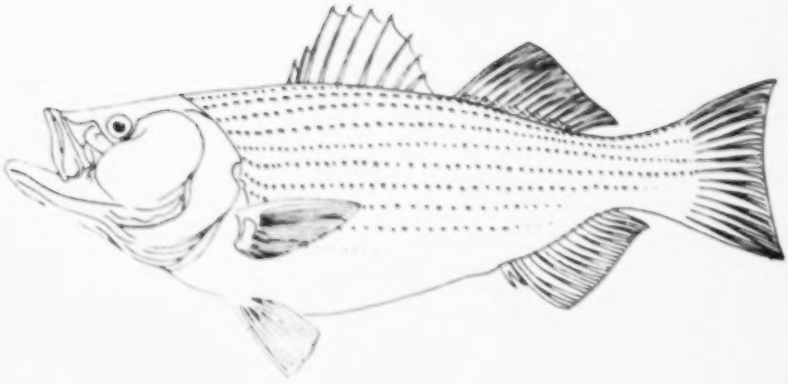


Walleye

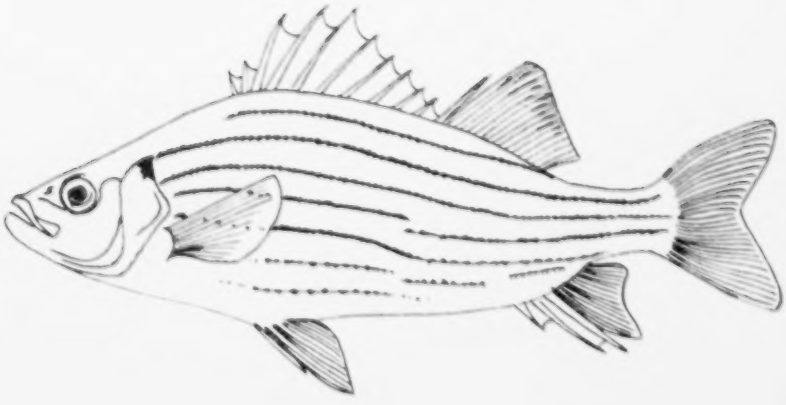
23. a. Drum Family



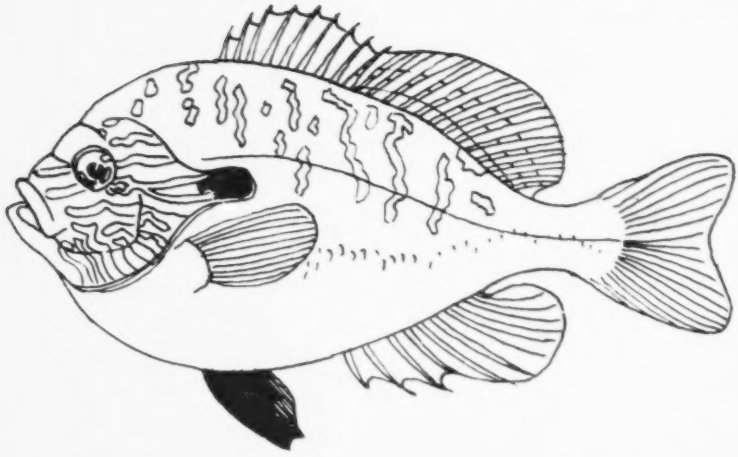
Drum



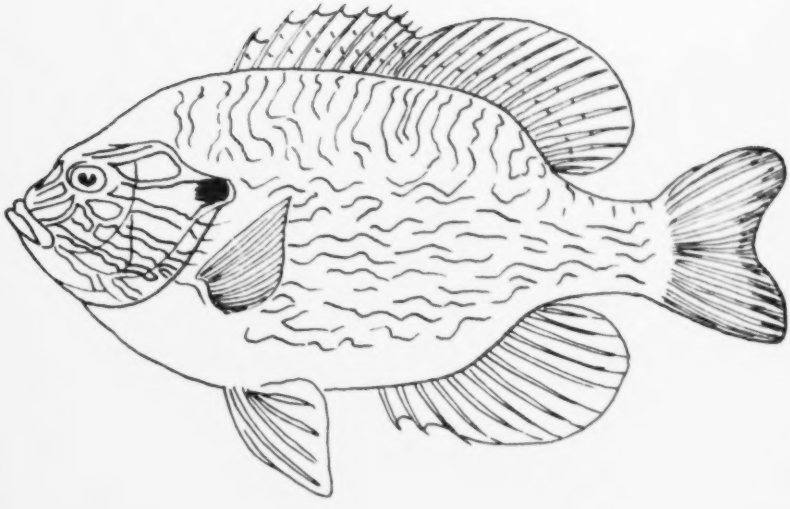
Striped Bass



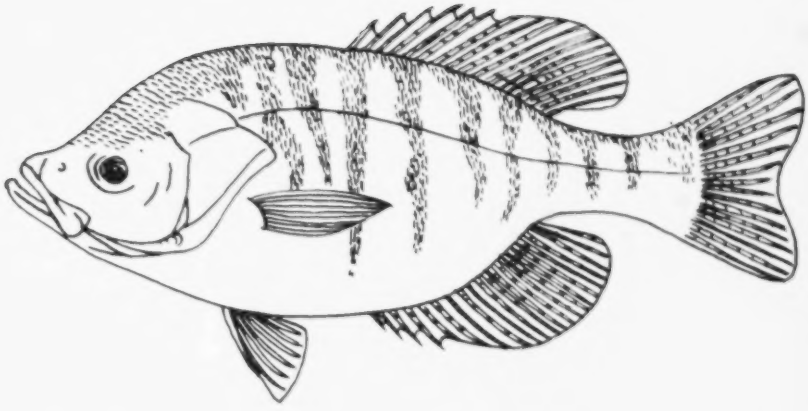
Yellow Bass



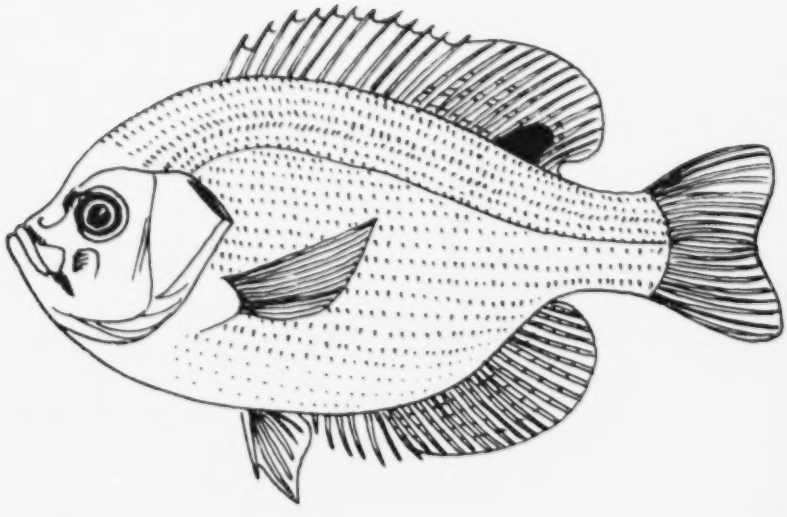
Longear Sunfish



Pumpkinseed

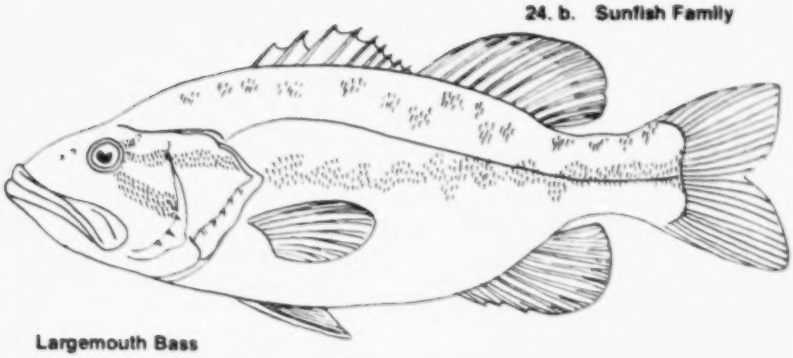


White Crappie



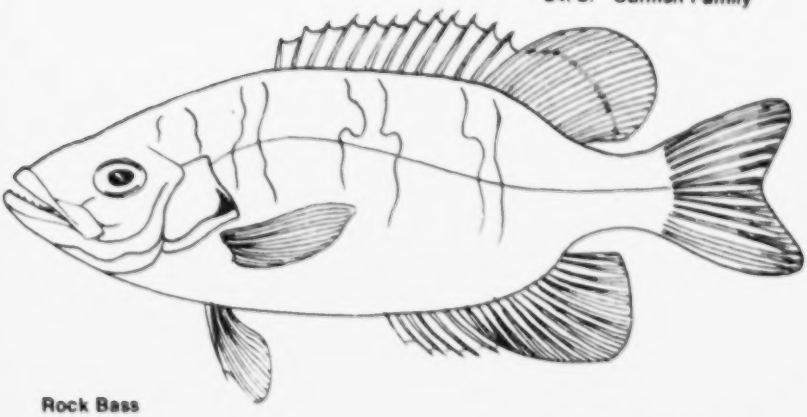
Flier

24. b. Sunfish Family



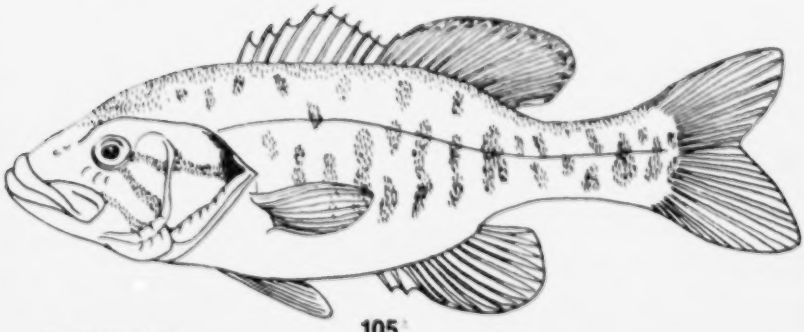
Largemouth Bass

24. b. Sunfish Family



Rock Bass

24. b. Sunfish Family



Smallmouth Bass

105

GLOSSARY

A

acid mine drainage: waters of low pH (less than 6) from mining areas.

acid waters: waters having a pH less than 7.0, streams influenced by acid mine drainage commonly have a pH less than 6.0

acute toxicity: any short-term exposure that results in injury or death.

adipose fin: small fleshy lobe on top of caudal peduncle between dorsal and caudal fins of a fish.

aesthetic quality: characteristics that are pleasing to the eye, such as the beauty of a natural stream or watershed.

algae: small plants which lack roots, stems, flowers, and leaves; living mainly in water and using sunshine as an energy source.

alkalinity: a measurement of a water's ability to neutralize acid.

animal wildlife: undomesticated animals including mammals, birds, reptiles and amphibians.

aquatic community: all the groups of plants and animals occupying a common water body.

aquatic flora: plants that spend all or part of their life cycles in the water.

aquatic habitat: all of the areas in a stream, lake or wetland that are occupied by an organism, population or community.

aquatic life: those plants and animals that spend all or part of their life cycles in streams, lakes or wetlands.

aquatic organism: a plant or animal that spends all or part of its life cycle in water.

B

bacteria: single-celled organisms lacking chlorophyll.

bioaccumulation: the process whereby a toxic substance becomes concentrated within organisms.

biota: the plants and animals within a certain area.

bloom: a nuisance growth of algae and/or higher aquatic plants in a body of water, often related to excessive nutrients.

blue-green algae: a group of algae that often, but not always, appears green in color.

BOD: Biochemical Oxygen Demand, a measure of the amount of oxygen used in the breakdown of organic matter in water. The greater the degree of organic pollution, the greater the BOD.

bottom sediments: material, such as sand and silt, that is found on the stream bed.

brine water: water that is high in salt content.

C

carcinogen: a cancer-causing agent.

carnivore: flesh-eating organism.

D

decomposition: the breakdown of organic matter by bacteria and fungi.

detritus: partially decomposed organic matter, such as tree leaves, in the water.

diatoms: microscopic, single-celled algae.

diversity: the number of different types of organisms in an aquatic community.

DO: Dissolved Oxygen, a measurement of the oxygen in water; oxygen is necessary for the life of fish and other aquatic organisms.

dredging: removal of material, usually from the bottom, of water bodies.

E

ecological stress: any condition that can alter the food chain or quality of the environment.

ecology: the relationship of living things to one another and their environments or the study of such relationships.

effluent: a discharge of partially or completely treated pollutants into the environment; generally used to describe discharge into water.

emergent plants: plants rooted in the bottom of a stream, lake or wetland, that rise above the water surface.

entomology: the study of insects.

environment: all the conditions affecting the life, development and survival of an organism.

erosion: the wearing away of the land surface by wind or water.

eutrophic: a highly productive water body, usually caused by the input of large amounts of nutrients.

eutrophication: *Natural eutrophication* is the process of lake aging. *Cultural eutrophication* occurs when nutrients are added from agricultural runoff, sewage or other sources.

F

fauna: animals.

floodplain: low areas of land surrounding water bodies which contain the overflow of water during a flood.

fecal coliform bacteria: the portion of the coliform group which is present in the gut or feces of warm-blooded animals. The presence of fecal coliform bacteria in water is an indication of pollution and potential human health problems.

filamentous algae: small plants, recognizable as attached, hair-like growths, often appearing as waving strands in the water.

filter feeder: those organisms that use a filtration device to strain food from the water, including types of insects, mussels and fish.

flora: plants.

food chain: a transfer of energy in a sequence of organisms (algae, fish, etc.) in a community in which each member of the chain feeds on the member below it.

forested wetland: a wetland dominated by trees over twenty feet in height, commonly called a swamp.

G

grazing insects: insects that feed on plant material growing on the substrate.

H

habitat: the area in which an organism lives.

hard water: water containing dissolved minerals such as calcium, iron and magnesium. The most notable characteristic of hard water is its inability to lather soap.

herbicide: a chemical used to destroy or control plant growth.

herbivore: a plant-eating organism.

I

indicator: anything that, by its presence or absence, shows an environmental condition.

inorganic: any compound not containing carbon.

intolerant species: species that are sensitive to and affected by water pollution.

invertebrate: animal without a backbone.

L

larva: the immature form of an animal that is incapable of reproduction, lacks wings and is totally different from the adult.

lateral line: a system of sensory organs along each side of a fish's body which are sensitive to vibrations.

M

macroinvertebrate: aquatic animals without a backbone that are large enough to be seen by the naked eye.

meanders: the bends in a winding stream or river.

metamorphose: to change into a differnt form, such as from an insect pupa to an adult.

mollusk: soft-bodied (usually hard-shelled) animals such as clams and snails.

monitoring: determining water quality on a regular basis.

mutation: the result of a change in the genes of an organism.

N

native fauna: animals that were originally found in an area.

natural water quality: the physical, chemical and biological conditions of a water body which have not been degraded or enhanced by human activity.

nodulose: having the appearance of being made up of nodules.

nonpoint source pollution: a type of pollution whose source is not readily identifiable as any one particular point, such as pollution caused by runoff from streets and agricultural land.

nutrient: any substance which is necessary for growth of living things (i.e., phosphorus, nitrogen and carbon).

nymph: a juvenile, wingless stage of an insect.

O

omnivore: an organism which eats both plants and animals.

order: taxonomic grouping of related families of organisms.

organic material: any compound containing carbon.

P

parasitic: a plant or animal that lives in or on another organism (the host) and derives its food from the host.

pathogenic: capable of causing disease.

periphyton: tiny plants and animals living on submerged surfaces.

pesticide: a chemical used to destroy or control the growth of animals or plants.

pH: the measurement of acidity or alkalinity on a scale of 0-14. A pH of 7 is neutral, less than 7 is acidic, and more than 7 is alkaline (basic).

phosphorus: an essential plant nutrient that, in excessive quanities, can contribute to the eutrophication of water bodies.

photosynthesis: process by which green plants use sunlight to produce food.

phytoplankton: tiny aquatic plants (algae).

plankton: tiny plants and animals that drift in water.

point source pollution: a type of pollution that can be easily traced to a particular point, such as a dischrage pipe.

pollutant: any substance that harms the environment.

pollution: the presence of any substance that harms the environment.

predatory: living by capturing and feeding upon other animals (the prey).

prey: an animal hunted and killed by another animal (the predator).

primary producers: the first (lowest) level in the food chain; composed of green plants.

pupa: the stage during which an insect is enclosed in a protective case while changing from larva to an adult.

R

recreation water quality: the ability of water to be used for swimming, boating, fishing or any activity that involves the use of water.

respiration: the exchange of carbon dioxide with oxygen from the environment by a plant or animal.

riffles: fast flowing, shallow areas of a stream characterized by turbulence.

riparian: pertaining to an organism which lives or grows on the shore of a lake, stream or other water body.

runoff: water from rain, snowmelt, or irrigation that flows over the ground surface and returns to streams, lakes or wetlands.

S

sediment: soil, sand, and minerals washed from land into waterways.

sedimentation: the process by which soil particles (sediment) enter, accumulate and settle to the bottom of a waterway.

septic odor: the rotten-egg smell produced by the decomposition of organic matter in the absence of oxygen.

sewage: the organic waste and wastewater produced by residential and commercial establishments.

sewage fungus: filamentous bacteria associated with organic pollution.

sewage treatment plant: a facility designed to remove organic pollutants from wastewater.

shellfish: an aquatic invertebrate animal with a shell, such as a mussel or a clam.

shredder: a type of insect that feeds on plant material.

silt: fine particles of soil or rock that can be picked up by air or water and deposited as sediment.

siltation: the process of silt settling out of the water and being deposited as sediment.

sludge beds: any heavy deposit of organic material found below point source discharges, usually black and foul-smelling.

substrate: the surface upon which an organism lives or is attached.

spawning areas: regions in streams, rivers or lakes used by organisms for laying and fertilizing eggs.

species: a unit of classification for a group of closely related individuals.

stream bed: the bottom of a stream where the substrate and sediments are found.

stream depth: a measurement of the depth of a stream from the water's surface to the stream bed.

stream flow: the amount of water moving in a stream in a given amount of time.

swamp: common name for a forested wetland.

specific conductance: a measurement of the water's ability to conduct electricity.

T

terrestrial life: those plants or animals that spend most or all of their life on land.

tolerant species: an organism that can exist in the presence of a certain degree of pollution.

topography: geographical features of a region, both natural and artificial (hills, rivers, cities, roads, etc.).

total coliform bacteria: a group of bacteria that are used as an indicator of drinking water quality. The presence of total coliform bacteria indicates the possible presence of disease-causing bacteria.

toxicity: a measurement of how poisonous or harmful a substance is to plants and animals.

toxin: a substance that is harmful to humans and other organisms.

tributary: side stream or river flowing into a main river.

trophic level: a link in the food chain. The first trophic level (lowest) consists of producers (green plants); the second level of plant eaters; and the third level of meat eaters. Bacteria and fungi are organisms in the decomposer trophic level.

trubidity: degree of cloudiness due to material suspended in the water.

W

wastewater: water carrying unwanted material from homes, farms, businesses and industries.

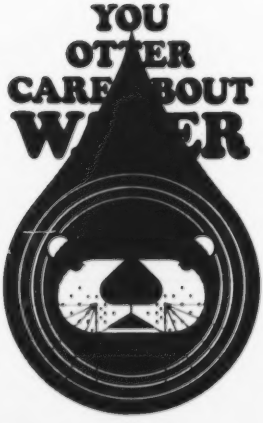
water quality: the condition of the water with regard to the presence or absence of pollution.

watershed: all the land that serves as a drainage for a specific stream, river, lake or wetland.

wetland: an area covered with shallow water or that has wet soil at least part of the year, commonly called swamps or marshes.

Z

zooplankton: tiny aquatic animals.



Water Watch Program

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Kentucky Natural Resources and Environmental Protection Cabinet
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